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WILBUR CLINTON KNIGHT.

THE AMERICAN GEOLOGIST,

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THE

AMERICAN GEOLOGIST.

VOL. XXXIII. JANUARY, 1904. No. 1.

WILBUR CLINTON KNIGHT.

By S. W. WILLISTON.

PORTRAIT—PLATE I.

In the death of Wilbur Clinton Knight at the early age of forty-four, science has sustained a loss, which can only be truly appreciated by those who knew him best. A man of rigorous rectitute of character, enthusiastic to a greater degree than is common among scientific men even, tireless in activity, and sincerely devoted to science because of the love of science, the results of the work he accomplished in the comparatively few years of his mature powers will be known best only to the university which he served so well, and to those friends elsewhere who came into close relationship with him. It was my pleasure to be a frequent correspondent of Dr. Knight for nearly ten years, and to have spent weeks with him in camp and at his own fireside. The news of his death came as a shock while on my way to visit him in Laramie in response to a most generous invitation. I had long since learned to trust him implicitly as an upright gentleman and as a friend.

Professor Knight, the son of a farmer, was born at Rochelle, Illinois, Dec. 13, 1858. His father, David A. Knight, removed while yet the son was a boy to a farm near Lincoln, Nebraska, then near the limits of civilization on the plains. Pioneer life developed in the son those traits which have brought success to many another western lad, self reliance, vigor of purpose and of body, energy and ambition. The naturalist was born in the country boy, and those keen powers of observation for which he was distinguished were trained as perhaps nothing else would have trained them. The fauna and flora and geology of his prairie home surroundings became familiar to him in a way that shaped his whole future life. While the larger part of his attention in later years was devoted to geological and chemical pursuits, I have reason to believe that, could he have been left free to follow his own inclinations, he would have preferred to give his life to purely paleontological and stratigraphical studies, and he never fully reconciled himself to his limitations.

He graduated at the University of Nebraska in 1896, in the scientific course. He left his country home, where there was little stimulus for intellectual life, to enter college at an age when most young men graduate, and worked his way through his course by setting type at night time. Immediately after his graduation, he went to Wyoming to serve as an assistant geologist on the territorial survey. In this position, and as an assayer and superintendent of mines of Colorado and Wyoming he served until called to the professorship of Geology and Mining at the newly founded University of Wyoming, at Laramie, in 1893, a position which he held uninterruptedly, with the added duties, concurrently or successively, of geologist of the Wyoming experiment station, curator of the State Museum, state geologist, and principal of the School of Mines of the State University, until his death from peritonitis, July 28 of the past year. He received the degrees of M.A. and Ph.D. from his alma mater in 1893 and 1901, and had also spent some time in graduate study at the University of Chicago. He was for years a fellow of the Geological Society of America, and was a member of the Institute of Mining Engineers, of the National Geographic Society, and of other societies.

During the ten years of his incumbency of the professorship at the University of Wyoming, professor Knight found time, notwithstanding the multiplicity and arduousness of his labors, to publish many valuable contributions to geological and paleontological science, a list of which, as compiled by his colleague, professor A. Nelson, will be found appended herewith. Indeed those who knew him can only be surprised at the tireless and incessant activity which enabled him to accomplish so much of real value. But his publications tell only a part of what he did, and that too with oftentimes the most meagre means at his command and amid discouragements which few can appreciate. Almost isolated from companionship with scientific men in his own field of work, with but little literature and means for comparative studies, his work was largely that of a pioneer, preparing the way for others. He found time among other things to bring together collections in paleontology of which any university might be proud. More than fifty tons of valuable fossils, chiefly vertebrates, were obtained for the university by his patient effort, and some of those young men whom he helped to train are now gaining reputations for themselves in paleontology. Only a few months before his death he published an excellent extended list of the birds of Wyoming, based upon material largely the result of his own labors.

The larger part of his published papers, it will be seen, were devoted to economic geology, and the state owes him a debt of which I trust it feels fully conscious. Nevertheless, he published not a few papers of value on the stratigraphy, paleontology and natural history of Wyoming. In stratigraphic geology his chief services were in the more accurate mapping of parts of the state, in the recognition of the Lower Permian, in the recognition of the so-called Triassic or Red-beds as being, in part at least, of Permian age, in the more accurate determinations of the Jurassic horizons, etc. In paleontology he described a number of new forms of plesiosaurs. ichthyosaurs, fishes, etc. Much of the material which he accumulated is new to science and of much interest, and it is unfortunate that he did not have the time and opportunity to study this material more fully. His limitations were those of a pioneer state—multiplicity of things to do, and the lack of means which can only be brought together by time. And his merits are largely those of a pioneer, merits which are often not appreciated at their full value by the laboratory scientist.

As to his personal character, I am permitted to quote from a letter from a mutual friend, and colleague of professor Knight for ten years, professor E. E. Slosson:

"Professor Knight habitually overworked himself day and night; he was not strong in constitution. He built his own assay furnaces, put up partitions and desks and bought his own books when appropriations were insufficient, as they must always be in a new university. He was unfailingly courteous and kind hearted in his relations with others, never wounding feelings and unselfishly doing more than his share of the duties which came in his way. He was outspoken against shams and pretensions of all kinds, and his opposition to the present methods of exploiting mines in the west often brought down upon him the displeasure of promoters, and caused efforts to be made to force him out of his position. His assays were fearless and honest. He was tempted at times by offers of large salaries to go into mining work, but he refused them always because of his love for science."

All this I can corroborate. It was a few weeks before his death that he wrote me he had been sadly tempted to accept an excellent position in mining work with a salary of five thousand dollars a year, but he could not abandon his scientific work. The State had learned to trust him for his ability and fearless integrity, and he might have had many opportunities in business life had he desired. The appreciation of scientific merit comes slowly in the western states unless it leads immediately to the almighty dollar, and he who loves science for science's sake is usually regarded outside of his immediate circle of friends, with a feeling of mild contempt. More than anywhere else, I think, newspaper notoriety is necessary in the west to give fame to the "scientist." But professor Knight was not that kind of a man, and this must be taken into account in correctly appreciating his character. Nevertheless, after many years Wyoming did appreciate him, as was evident by the universal regret at his demise.

Professor Knight was married in 1889 to Miss E. Emma Howell, who survives him with four children. That his home life was a happy one I can certify from personal knowledge.

Professor Knight gave his life unselfishly and freely, without the recompense he deserved, and amid many discouragements, to his adopted State. His period of highest usefulness was only fairly begun, and his university had learned his real worth; his colleagues have only the kindest and most sincere words of appreciation for him as a man and as a teacher.

The State of Wyoming could do no better service to the youth of the state, no greater honor to itself than by erecting a fitting and lasting memorial at the university where he worked so faithfully, to the memory of professor Wilbur Clinton Knight, a sincere and a faithful man, and an earnest student.

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MORAINES AND ESKERS OF THE LAST GLACIATION IN THE WHITE MOUNTAINS.

By WARREN UPHAM, St. Paul, Minn.

During the quarter of a century since the publication of The Geology of New Hampshire, in 1874-78, by Prof. C. H. Hitchcock and his assistants, nearly all that is known of the terminal moraines (marginal and recessional moraines) of the continental ice-sheets has been ascertained. At the same time with that work on my native state, and partly in its third volume, the earliest elaborate descriptions of any parts of these moraines, with recognition of their character and origin, were published by Cook,* Chamberlin,† and the present writer.‡

Within a few years later, the outermost moraine was traced across northern Pennsylvania by Lewis and Wright;§ and it was followed onward by Wright through southern Ohio and Indiana.‖ Farther northwest, it was similarly traced with ensuing moraines of the glacial recession, by Prof. N. H. Winchell and myself in Minnesota and Iowa,¶ and by Todd in South and North Dakota.°

Correlating all these observations, Chamberlin twenty years ago published descriptions and maps of the complex system of the outer marginal moraines in all their course across the northern part of the east half of the United States, from Nantucket and Cape Cod to North Dakota and Assiniboia.**

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* *Geol. Survey of New Jersey*, Annual Rept., 1877, pp. 9-12; Ann. Rept., 1880, pp. 15-39.

† "On the Extent and Significance of the Wisconsin Kettle Moraine," *Trans., Wis. Acad. Nat. Sci.*, vol. iv, p. 201-234, 1878; "Le Kettle Moraine et les Mouvements des Glaciers qui lui ont donne Naissance," *Congres Internat. de Geologie, Compte Rendu*, session of 1878, pp. 254-268, Paris, 1880.

‡ *Geol. of N. H.*, vol. iii, 300-305, 1878; "Terminal Moraines of the North American Ice-Sheet," *Amer. Jour. Sci.*, third series, vol. xviii, pp. 81-92, 197-207, Aug. and Sept., 1879; "The Formation of Cape Cod," *Am. Naturalist*, vol. xiii. pp. 489-502, 552-565, Aug. and Sept., 1879; "The Succession of Glacial Deposits in New England," *Proc. A. A. A. S.*, 1879, vol. xxviii, pp. 299-310, 1880.

§ H. C. LEWIS, "The great Terminal Moraine across Pennsylvania," *Proc. A. A. A. S.*, 1882, vol. xxxi, pp. 389-398, 1883; H. C. LEWIS and G. F. WRIGHT, Report on the Terminal Moraine across Pennsylvania and western New York . . . Ohio, and Kentucky, *Second Geol. Surv. of Pa.*, Report Z, pp. lvi, 299, 1884.

‖ *Amer. Jour. Sci.*, third series, vol. xxvi, pp. 44-56, July, 1883; *Proc., A. A. A. S.*, 1883, pp. 202-208, 1884.

¶ *Geol. and Nat. Hist. Survey of Minn.*, Eighth Annual Report, for 1879, pp. 72-83, 1880; Ninth Ann. Report, for 1880, pp. 281-337, 1881.

° *U. S. Geol. Survey*, Third Ann. Rep., for 1881-82, pp. 396-8, 1883.

** "Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch," *U. S. Geol. Survey*, Third Ann. Report, for 1881-82, pp. 291-402, 1883.

Subsequently, our detailed knowledge of this subject has been much increased through extensive field work by Wright, Chamberlin, Salisbury, Leverett, Taylor, Todd, Fairchild, Hitchcock, Shaler, Woodworth, the present writer, and many others. It is also to be added, with some national pride, that two American geologists, Lewis in England, Wales, and Ireland, and Salisbury in Germany, respectively in 1886 and 1888, coming from their explorations in this country, were the first to recognize, and largely to map and describe, the great marginal moraines of the British and continental ice-sheets in Europe.

Earlier, however, than any of these studies, marginal moraine deposits, observed in the region of the White mountains in New Hampshire by Louis Agassiz, had been described by him, being attributed to a limited and late local glaciation by a remnant of the waning continental ice-sheet.* He wrote of the vicinity of Franconia and Bethlehem, N. H., west and north of the highest ranges of these mountains, and of Center Harbor and Meredith, at the northwest end of lake Winnipesaukee, south of the mountains, as follows:

Twenty-three years ago, when I first visited the White Mountains, in the summer of 1847, I noticed unmistakable evidences of the former existence of local glaciers. They were the more clear and impressive to me because I was then fresh from my investigations of the glaciers in Switzerland. And yet, beyond this mere statement of the fact that such glaciers once existed here, I have never published a detailed account of my observations, for this simple reason,—that I could not then find any limit or any definite relation between the northern drift and the phenomena indicative of local White mountain glaciers....This year, a prolonged stay among these hills has enabled me to study this difficult problem more closely.....

The finest lateral moraines in these regions may be seen along the hill-sides flanking the bed of the south branch of the Ammonoosuc, north of the village of Franconia. The best median moraines are to the east of Picket hill and Round hill. The latter moraines were formed by the confluence of the glacier which occupied the depression between the Haystack and Mount Lafayette and that which descended from the northern face of Lafayette itself. These longitudinal moraines are particularly interesting as connecting the erratic boulders on the north side of the Franconia range with that mountain mass, and showing that they are not northern boulders transported southwards, but

* *Am. Naturalist*, vol. iv, pp. 550-558, 1870; and *Proc., A. A. A. S.*, 1870, vol. xix, pp. 161-167, 1871. This paper is reprinted in full by PROF. C. H. HITCHCOCK in *Geology of N. H.*, vol. iii, pp. 234-288, 1878.

boulders from a southern range transported northwards. But by far the most significant facts, showing the great extent of the local glaciers of the White mountain range, as well as the most accessible and easily recognized, even by travelers not very familiar with glacial phenomena, are the terminal moraines to the north of Bethlehem village, between it and the northern bend of the Ammonoosuc river. The lane starting from Bethlehem street, following the cemetery for a short distance, and hence trending northwards, cuts sixteen terminal moraines in a tract of about two miles. Some of these moraines are as distinct as any I know in Switzerland. They show unmistakably by their form that they were produced by the pressure of a glacier moving from the south northwards. This is indicated by their abrupt southward slope, facing, that is, toward the Franconia range, while their northern face has a much gentler descent. The steeper side of a moraine is always that resting against the glacier, while the outer side is comparatively little inclined. The form of these moraines, therefore, as well as their position, shows that they have come down from the Franconia mountains. A few details concerning their location may not be out of place, in order that any visitor interested in the facts may readily find them without a guide. The ground to the north of Bethlehem slopes gently northward, and is not wooded for about half a mile from the street. Following the lane above mentioned, the first moraine reached skirts the edge of the wood, and near the houses of Mr. Phillips there are four others, more or less distinct, before reaching a little trout brook called "Barrett's brook." The lane descends more rapidly towards the brook than before; and, where the descent begins to be steep, the eye commands the space between the brook and a higher ground, on which stands a house owned by Henry McCulloch. Over that interval six very fine moraines may be counted, one of which is perhaps the finest specimen of a terminal moraine I have ever seen. Beyond McCulloch's there are five more, not quite so distinct. The ground beyond the termination of the glacier of the Rhone, in Switzerland, is celebrated for its many distinct concentric moraines; but here we have a field over which, within the same area, a larger number of such moraines may be seen, and I believe that a pilgrimage to this spot would convert many a sceptic to the true faith concerning the transportation of erratic boulders, especially if he has seen the glaciers of the Rhone, and can compare the phenomena of the two localities.....

Moraines similar to those observed on the northern side of the White mountains exist also on their southern side, in the vicinity of Center Harbor. Lateral moraines may be traced at the foot of Red hill, a little above Long pond; also, along Squam lake. Median moraines are very distinct near Center Harbor hotel. Terminal moraines are also numerous near Center Harbor, and in the neighborhood of Meredith. At the southern end of Red hill the lateral moraines bend westward, and show their connection with the terminal moraines. These facts, taken in their relation with those enumerated above, show that there were local glaciers on the southern as well as the northern slopes of the White mountain ranges, moving in opposite directions; those on the northern slope moving northward, and those on the southern slope moving southward.....

All these moraines and traces of local glaciers overlie the typical or northern drift, so called, wherever the latter has not been entirely swept away by the local glaciers themselves, thus showing that the great ice sheet is anterior to the local glacier.....At least, wherever I have recognized traces of circumscribed glaciers in regions where they no longer exist, it has always appeared to me that the minor areas covered by ice were remnants of a waning sheet of greater extent.....

Having in June two years ago carefully examined the ground northward from Bethlehem, which Agassiz thus described, I fully concur in his view that the morainic drift there was brought from the south, being amassed along the northern edge of ice fields that sloped down from the north ends of the Franconia and Twin Mountain ranges; but I could not trace the many and mainly parallel morainic ridges or series of knolls and hillocks which his description led me to expect. Instead of separate and well defined small frontal moraines, like those which I had seen in the glens and valleys around Ben Nevis and Scawfell,* marking intervals of halting in the retreat of the latest local glaciers, the ridged and knolly drift deposits north of Bethlehem appear to me to be an indivisible and promiscuous morainic belt, running there from east to west, with a width of one to one and a half miles, quite like the typical moraines of the continental ice sheet in their course through Minnesota and adjoining states.

Besides, from my many excursions and railroad surveying in the White mountain region, and especially about the base of Mt. Washington, I can say confidently that recessional moraines of local glaciation, similar to those so admirably and plentifully displayed in the vicinity of the highest peaks of Scotland and England, are generally absent or rare among these highest mountains of the northeastern United States. Perhaps their best example is the one described by Stone, in the Androscoggin valley where it crosses the line between New Hampshire and Maine.† But probably [illegible] search in the great valleys and ravines will reveal numerous examples of such narrow

* [illegible] June, 1896.

† [illegible] Sci., third series [illegible]

local moraines, which, on account of their usually scanty mass, have not hitherto been observed in that wooded country.

During parts of the years 1871-78 I was employed on the Geological Survey of New Hampshire, and in the later half of that time partly on surveys for the railroad extension from the Twin Mountain House to the Fabyan House and onward to the foot of the Mt. Washington railway. In 1877 and 1878 I began, on Cape Cod, the New England islands, and Long Island, my field observations and studies of the terminal moraines of our continental ice-sheet, which were continued through nearly twenty years in Minnesota, the Dakotas, and Manitoba. In 1897 I visited Europe, and saw its continental moraines in Germany and Denmark, and the moraines of local glaciers in Switzerland and in Great Britain.

It was, therefore, one of my chief motives, in visiting the White mountains again, in 1901, to look for morainic deposits, whether of their continental or local phases. By railroad travel, I saw again the Ammonoosuc river from its mouth at Woodsville to its highest source in the Lake of the Clouds on Mt. Washington.

The morainic belt close north of Bethlehem, which I then first examined, was found to represent the continental type of moraines, and to have a considerable extent from east to west in the Ammonoosuc valley. Beyond that portion, traced from the vicinity of the Twin Mountain House westward to the south part of the village of Littleton, a distance of twelve miles, this moraine doubtless turns to the southwest and south, and sweeps circuitously around the highest ranges of the White mountains, to connect again, from the east and north, with the east end of the part so traced. Its small hills and short ridges usually rise 15 to 30 or 40 feet above the intervening and adjoining hollows, but sometimes to hights of 50 to 100 feet; and in many places, as at Littleton, its accumulations are more massive than at Bethlehem.

The material of this belt is chiefly till, with some modified drift, as kames, or knolls of gravel and sand. The contour is very irregular, in multitudes of hillocks and little ridges, grouped without order or much parallelism of their trends. Everywhere in and upon these deposits, boulders abound, of all sizes to 5 or rarely 10 feet, or more, in diameter, being far more plentiful than in and on the adjoining smoother tracts of till throughout this region.

An area of 2,000 to 2,500 square miles may be expected to be mapped inside the circuit of this *Bethlehem moraine,* as it may be named, reaching perhaps south to Center Harbor, and probably east into Maine. It was the latest moraine belt of the broad or continental type in the United States, unless some moraine of the same kind and of the same age, or more recent, may surround a part of the Adirondack mountains or a part of central Maine culminating in Mt. Katahdin.

When the icefields were still more reduced, shrinking to form separate glaciers in the valleys and ravines of the great mountain ranges, their departure seems probably to have been more rapid than in the case of the last remnants of the British ice-sheet, with fewer pauses allowing opportunity for the formation of characteristic narrow valley moraines, like those of Ben Nevis and Scawfell. Such moraines I saw only near the old White Mountain House, within 20 to 30 rods north and west from it, about one mile west of the Fabyan House. These little ridges of drift, parallel and four or five in number, well strewn with boulders, rise 5 to 10 feet above the nearly level ground, and extend from north to south, transverse to the Ammonoosuc valley, at its northern side. Other valley moraines were looked for, but were nowhere seen, in the distance of about six miles eastward to the foot of the steep west side of Mt. Washington, where it is ascended by the railway.

A re-entrant angle of the remnant of the ice-sheet when it was forming the Bethlehem moraine, having its apex near the Twin Mountain House, probably permitted the ice front to turn thence northward along the west side of Cherry mountain. In the later glacial recession, the same indentation of the ice border, retreating to the east and southeast, caused a very interesting esker series,* partly complex and partly a single conspicuous ridge, to be extended nearly along the center of the Ammonoosuc valley for the distance of four miles between the Twin Mountain and Fabyan houses, and for at least a mile and a half farther to the east and south. Large portions of the esker, if it was originally continuous, have been eroded by the

* First described by me, for its southeastern half, in *Geology of N. H.*, vol. iii, p. 62, 1878.

river, and a part which remained, known as "The Giant's Grave," was leveled and removed from the site of the Fabyan House. This ridge, best seen from one-fourth to three-fourths of a mile east and southeast of Fabyan's, and again, after an interval of erosion, to three-fourths of a mile farther south, consists of sand and gravel, with all its cobbles rounded by water-wearing, of all sizes to a foot, and rarely one and a half feet, in diameter. Its hight above the river and its bottomland varies from 25 to 50 feet.

This series of eskers, traced thus about six miles, near the west base of the Mt. Washington range and north and west of the principal and central area of the White mountains, was certainly formed by a glacial river, inclosed on each side by walls of the departing ice-sheet, and flowing away from that area, that is, from southeast to northwest and west, in the same direction as the present Ammonoosuc river. It demonstrates, like the Bethlehem moraine, though for a somewhat later stage of the glacial melting, that a remnant of the general ice-sheet was rapidly and continuously melting back on this tract from northwest to southeast, lingering latest on the flanks of the Mt. Washington and Mt. Willey ranges.

After the melting of the general sheet of ice which had been accumulated during the Glacial period, no local valley glaciers survived in this region, as we know from the absence of valley moraines. But for some geologically short time, while the mountain region was still ice-covered, excepting its highest ridges and peaks, the currents of the ice on the north and west sides of this area were reversed from their former course during the Ice age; and in the large valleys on the west, north, and east, the glaciation during that short time generally passed down the valleys under the guidance of the grand topographic features, which through the preceding long period of glaciation had been generally overridden by the southeasterly moving ice-sheet.

Professor Hitchcock observes* that many large boulders of the coarse-grained gray granite of Mt. Deception, close north of the Fabyan House, were transported to the fields east of the Twin Mountain House, that is, westward down the Ammonoosuc valley, a distance of four miles. If the rate of this de-

* *Geology of N. H.*, vol. iii, p. 242, 1878.

flected glacial movement averaged 200 feet yearly, it would indicate a duration of at least a hundred years for the time of reversal from the preceding general glaciation.

A most astonishing profusion of large and small boulders, mostly of angular forms and little worn, supplied from the same granite of Mt. Deception, strew and fill an extensive undulating and partly knolly deposit of till, beginning a third of a mile east of the Fabyan House and reaching easterly about three miles to a picturesque rock gorge and falls of the Ammonoosuc. These boulders, from 2 or 3 feet to 25 feet in diameter, were doubtless contained in the almost stagnant lower part of the ice-sheet, by which they were carried so short a distance to the southeast from their parent ledges, while the higher parts of the ice moved much faster, passing onward over the southern extension of the Washington or Presidential range.

In closing this paper, mention should be made of an interview with Mr. Allen Thompson, a veteran land surveyor, who was the guide and companion of Agassiz during ten days of his excursions in the region around Bethlehem in the summer of 1870. Starting from the Agassiz House in Bethlehem (so named because he boarded there during a part of that visit to the mountains, the house being then newly built for summer tourists), I walked very early on the morning of June 28, 1901, to the summit of the road leading toward Franconia past the west base of Mt. Agassiz (formerly called Picket hill). On the way I called at a house in the south edge of the village for a drink of water, and, inquiring about Agassiz, I was much surprised and pleased to find that my questions were addressed to this old surveyor and mountain guide. He told me that Agassiz, in his conversation and manners, "was the most interesting man he ever knew." Eighteen years later, Mr. Thompson, being then seventy-four years old, spent seventy-three nights of the summer and autumn of 1888 in camping-out during land and timber surveys among these mountains.

THE DISTRIBUTION AND SYNONYMY OF PTYCHOSPIRA SEXPLICATA (WHITE AND WHITFIELD).

By D. K. Greger, Fulton, Missouri.

In Vol. VIII, Pt. 2, Paleontology of New York, professor Hall proposed the term *Ptychospira,* for certain coarsely plicated shells previously referred to the genus *Retzia* of King, with the somewhat rare *Retzia sexplicata* White and Whitfield,* as the only known American species. This species is frequently met with in the Kinderhook of Missouri, and while being a rare species in number of individuals, it has been recorded from numerous localities, under different names.

Mr. S. A. Miller† figured and described this species under the name *Retzia plicata,* from a collection of Chouteau fossils made by Mr. R. A. Blair of Sedalia, Mo. The horizon from which Miller's specimens came is the "Upper Chouteau" of Swallow and while not rich in Brachiopoda the following species were identified by the writer in a small collection furnished by the late O. A. Crandall, who collected in Miller's type locality. *Ptychospira sexplicata, Productus blairi, Productella arcuata, Spirifer osagensis, Camarotoechia tuta, Camarotoechia cooperensis, Spirifer latior.* The specimens of *P. sexplicata* from this locality seldom exceed 8 mm. in length, 9 mm. broad and 4 mm. in thickness.

At the base of the Kiesenger bluff, just above Warsaw, Benton county, Missouri, a number of well preserved specimens of *P. sexplicata* were collected from a drab, argillaceous limestone, stratigraphically lower than the typical exposures of Choteau in Cooper county. With them are associated: *Pugnax missouriensis, Leptaena rhomboidalis, Orthothetes inflatus, Camarotoechia cooperensis, Spirifer missouriensis, Spirifer latior, Spirifer peculiaris, Reticularia cooperensis, Productella arcuata, Dielasma popeana.*

In the Chouteau limestone (*sensu stricto*) at Chouteau Springs, Cooper county, Mo., *P. sexplicata* is of rare occurrence, the writer having found but four specimens in as many

* *Proc. Boston Soc. Nat. Hist.*, vol. viii, page 294, 1862.

† *18th Ann. Rep. Ind. Geol. Nat. Hist. Sur.*, 1894, p. 316, pl. 9, figs. 29-31.

years collecting. The shells from this locality are small, but well preserved and seem to be confined to a single zone associated with *Acambona osagensis, Camarotoechia cooperensis, Pugnax missouriensis, Reticularia cooperensis, Spirifer missouriensis, Spirifer latior, Spirifer peculiaris* and *Spirifer osagensis.*

In May, 1900, professor Rowley* figured and described this shell under the name *Retzia? raricosta,* from the division No. 14 of the Louisiana, Pike county section. It is quite rare at this locality and never reaches dimensions greater than 7 mm. long, 8 mm. broad and 4 mm. in thickness. With it are associated *Ambocoelia levicula, Athyris lamellosus, Camarotoechia cooperensis, Camarotoechia tuta, Cleiothyris roissyi, Cleiothyris tenuilieneata, Cyrtina burlingtonensis, Dielasma burlingtonensis, Dielasma occidentale, Dielasma rowleyi, Nucleospira obesa, Productella arcuata, Productella concentrica, Productus laevicosta, Reticularia cooperensis, Rhipidomella burlingtonensis, Rhipidomella diminutiva, Rhipidomella thiemei, Rhynchopora pustulosa, Seminula bisinuata, Spirifer forbesi* and numerous crinoids, corals and gasteropods.

Near Cedar Gap, Wright county, Missouri, in the North View shale of Weller, *P. sexplicata* is of not uncommon occurrence, being found in association with *Cyrtina acutirostris, Athyris lamellosus, Rhipidomella missouriensis, Spirifer marionensis, Spiriferina clarksvillensis, Nucleospira barrisi, Reticularia cooperensis, Schizophoria swallovi, Camarotoechia cooperensis* and *Orthothetes inflatus.* The specimens from this locality are the largest so far observed, the average measurement of twelve of the best preserved shells being 11 mm. long, 12 mm. broad, 5 mm. in thickness.

P. sexplicata is also found in the very interesting shale deposit at Fern Glen, St. Louis county, Mo. The writer's collection contains three specimens collected at this locality in association with *Athyris incrassata, Athyris lamellosus, Athyris prouti, Leptaena rhomboidalis, Productella arcuata, Productus burlingtonensis, Spirifer grimesi, Spirifer forbesi, Spirifer peculiaris, Rhipidomella missouriensis, Schizophoria swallovi* and *Orthothetes cf. inflatus.*

Among some specimens recently received from Mr. Frank Springer, from the Lake Valley Mining District of Sierra

* *American Geologist*, vol. xxv. May, 1900. Page 266, Pl. V. fig's 34-37.

county, New Mexico, there occurs one somewhat crushed specimen of *Ptychospira* the general expression of which corresponds in every respect to *P. sexplicata.* The exact horizon of the specimen is not known since the lot contained specimens of the Brachiopoda of the two beds, No. 7 and No. 8 of Springer's section.*

BEDFORD CYRTOLITE.

By LEA McI. LUQUER, New York.

The cyrtolite from Bedford, N. Y., was found in the great pegmatite vein which constitutes the feldspar quarry owned by the late P. H. Kinkel. This region is one showing evidences of a violent dynamic action, and lies in the rather limited area of "augen-gneiss" described by Luquer and Ries.†

The specimens were obtained from four different pockets, included between feldspar on one side and muscovite and smoky quartz on the other.

The mineral occurs generally massive, filling the veins or pockets to a width of about one and a half inches, with a tendency to form rough tetragonal forms with curved faces on the side in contact with the mica and quartz.

A careful examination shows great lack of homogeneity and the massive material varies in color from dark brownish-black, with pitch-like or adamantine lustre (in what appears to be the core portion) to a lighter grayish-brown with much less marked lustre. The color of the crystals varies in the same way, depending on whether they are fresh or altered.

In contact with the feldspar the color is chocolate-brown with brighter lustre.

The specimens, especially the lighter colored portions, quite generally show the presence of yellow earthy or scaly uraconite, yielding tests for uranium and sulphur.

The occurring forms of the crystals are the unit pyramid (111) in combination with the second order prism (100), producing a rhombic-dodechedral aspect. The pyramid faces are strongly curved and the crystals show a marked tendency to

* *American Journal of Science*, vol. xxvii, Feb. 1884. Page 97-108.

† The "Augen-gneiss" Area, Pegmatite Veins and Diorite Dikes at Bedford, N. Y., By L. McI. LUQUER and H. RIES. AM. GEOL., vol. xviii, Oct., 1896.

composite parallel growth. At this locality the forms are not the prism (110) and second order pyramid (101) reported by J. P. Cooke as occurring on the Rockport, Mass., cyrtolite.*

The mineral is infusible, loses color, glows, does not become magnetic when treated on charcoal and is practically insoluble in hydrochloric acid. The hardness is about six, being just marked with steel. The lighter portion appears to be softer and less tough than the blacker (core) material. The mean specific gravity of three portions of the grayish-brown material is 3.5761, and of the brownish-black (core) material 3.8441.

A microscopic examination of a thin section showed that the material was undoubtedly decomposed and that the change from the darker to the lighter portions was due to the progress of the alteration and also to the presence in the former of a large number of minute black inclusions. These dust-like black inclusions are probably uraninite, as the darker portions yield much stronger blowpipe tests for uranium than the lighter portions. The higher specific gravity of the blackish (core) material would also corroborate this theory.

In view of the evident lack of homogeneity and altered character of the mineral, an elaborate quantitative analysis was not deemed advisable, especially as the preliminary testing revealed the presence of uranium and probably of yttrium, involving very troublesome separations. The following average approximate determinations, by E. Waller, proved the mineral to be undoubtedly of the type of the described altered zircons: SiO_2 27.24, ZrO_2 53.56. Different samples yielded U_2O_8 1.14 to 4.35. Yttrium was probably present and traces of manganese, calcium and copper were also noticed. The uranium percentage is unusually high, being due to the black, dust-like inclusions of uraninite. The Mt. Antero, Colorado, cyrtolite, however, shows 4.82 percentage of U_2O_3.†

The Bedford mineral strongly resembles the cyrtolite from Llano county, Texas, which shows the same rough tetragonal crystals with curved faces.‡

The cyrtolite from Spruce Pine, Mitchell Co., N. C., has the same general type of crystals, but the color is much light-

* *American Journal of Science*, vol xliii, p. 228, 1867.
† Zeit. f. Kryst. u. Min. xxiii, 597.
‡ HIDDEN and MACKENTOSH, *Am. Jour. Sci.*, vol. xxxviii, p. 485, 1889.

er, being like that of the Buncombe Co., N. C., zircons. This cyrtolite shows no darker core. A mineral resembling cyrtolite has also been reported from Branchville, Conn.

The investigation indicates that the name cyrtolite is applicable to the material from this locality, especially as the name has already been used for the similar Llano Co., Texas, mineral, and the use of a new name would be quite unwarranted.

The cyrtolite specimens for examination were kindly furnished by George L. English & Co. and Mr. L. V. Case, the original finder.

ADDITIONAL MINERALS AT BEDFORD.

To the list of minerals of the pegmatite veins at Bedford, must be added:*

Beryl, of which many crystals of varying size have been found, pale bluish-green in color and showing slightly tapering hexagonal prismatic forms.

Uraconite, formerly reported as uranotil, but now proved to contain sulphur.

The former report of the finding of uraninite has been proved to be erroneous, the black core of the cyrtolite, with its more or less conchoidal fracture, pitch-like lustre and strong test for uranium, having been mistaken for pitch-blende.

Department of Mineralogy, Columbia University, N. Y., November 4th, 1903.

NOTE ON BLOCK MOUNTAINS IN NEW MEXICO.

BY CHARLES R. KEYES, Socorro, New Mexico.

When, at the last meeting of the Geological Society of America, the group of papers on the basin-range structure of mountains was under discussion, a number of especially instructive observations were elicited. Some of these notes have since found their way into print. Arising from the discussion there have appeared recently† some statements relating to the block mountains of New Mexico that seem to require some further explanation in order not to have them lead to very er-

* The "Augen-gneiss" Area, Pegmatite Veins and Diorite Dikes at Bedford, N. Y., AM. GEOL., vol. xiii, Oct., 1898.

† D. W. JOHNSON. AMERICAN GEOLOGIST, vol. xxxi. pp. 135-139, 1903.

roneous inferences. This is particularly so since specific illustrations cited are certainly not examples of the types figured.

The block mountains of central New Mexico belong to the type in which the faulting has taken place, for all practical purposes so far as can be observed, in a single plane, as professor Davis has urged. In most cases one great fault along a single plane adequately explains the phenomena observed. There are, no doubt, instances in which there are several fault-planes close together. In New Mexico the faulting here referred to is quite profound, being from 300 to 400 feet.

The Sandia mountains, east of Albuquerque, which rise 5000 feet above the level of the Rio Grande, present evidences of more than a single fault, but these faults are not nearly numerous enough to be regarded as true distributive faults. The major fault-planes are not more than three in number according to present observations, and are about a mile apart.

As for the Magdalena mountains, seventy-five miles south of Albuquerque, and thirty miles west of the Rio Grande, the conditions are identically the same as in the Sandias, except that the fault-scarp faces east instead of west, and there is no reason whatever of supposing that there is more than a single great drop. There are many other ranges which exhibit the phenomena presented by the Magdalenas. The Sierra Ladrones, the Manzano range, Sierra Oscura, Sierra San Andreas, Franklin range, Sierra de los Caballos, Fra Cristobal, and San Mateo mountains all show similar structures.

As diagrams of the New Mexican block mountains and particularly the two ranges specifically cited, the figures given in plate xii,* present some impossible geologic physics. From these figures very wrong conclusions must be surely drawn regarding the structure of the mountain ranges in question. Referring to the figures, the main inference is that the country is traversed by numberless parallel faults, a quarter of a mile to a mile apart, which run in a north and south direction, and that occasionally there occurs a great drop which produced the mountain range.

My own observation has been that the many small faults found on the backslopes of the Sandia and Magdalena ranges, for example, are not of the same category as the great fault

* *Loc. cit.*

which once formed one face of these mountains. They do not seem to be parallel with the great fault. If the main fault plane on the west face of the Sandias be considered as running exactly north and south, then of the small faults on the backslope those at the north end of the range strike southwestwardly; while those at the south end of the range strike northeastwardly. Only in the middle of the range are these small faults exactly parallel to the great fault. Moreover, there is in all of the mountain ranges mentioned a system of minor faults, running transversely to the axis of the range and nearly at right angles to the small faults of the backslope. In other words, the comparatively insignificant faulting of the backslope is tortional in nature. It appears to have arisen in the attempt of the brittle limestone forming the backslope to adjust itself to a complexly warped surface produced by the major faulting.

Now the Sandia range is a type of mountain geographically known as a Sandia. In Spanish the word means watermelon. In general appearance it is as if a barrel floated in the water—that is, with one end just submerged and the other end elevated. Such, when viewed at a distance of thirty miles, is the appearance of the Sandia mountain range rising out of the vast plains around it.

Mr. Johnson says: "This same structure (numerous parallel faulting planes) is shown still more beautifully in the Magdalena mountains, seventy-five miles farther south, where the development of extensive lead-silver mines has afforded excellent opportunity for the study of detailed features. Here again the range consists of a great monoclinal uplift, whose abrupt granitic escarpment faces eastward, while the more gentle slope of the limestone beds is towards the west. When seen from the northwest, the beautiful series of the smaller limestone blocks stand out with diagramatic clearness."

Now I shall not ascribe to the author just quoted the discovery of diagramatic clearness with which the blocks mentioned stand out, when viewed from the northwest. I well know the pride with which the people of the camp have long pointed out, from a distance of several miles, this evidence of block faulting on the backslope of the Magdalenas. I have gone over the ground with them and have demonstrated to their full satisfaction that at least some of the principal fault planes bounding some of the so-called blocks are not fault planes at all. The phenomenon is produced by differential weathering of thick alternating beds of hard limestone and soft shale. The backslope slants about thirty degrees. Moreover, after going through the mines lower down on the mountains, where many minor faults are to be noted in the tunnels, the slips were found to be all too insignificant to even show their presence on the weathered mountain slope.

As I take it, the physiographic history of the region is essentially as follows: The alteration in central New Mexico of narrow mountain ridges and broad plains presents some features which are not easily understood until the regions both to the eastward and westward are taken into consideration. In both directions the basin character of what is known as the bolson plain is soon lost. The plains become confluent and the mountain ranges more disconnected and finally altogether isolated. Still beyond, the plain alone exists without notable mountains. This condition persists on the one hand to the gulf of California, and on the other to the gulf of Mexico.

At the beginning of Tertiary time the region between the two great gulfs north to what is now the Colorado line must have been a vast lowland plain, with but faint relief features. A large part of this plain was on the bevelled edges of Cretaceous and older strata, as is well shown now in its remnants still clearly discernible. The Las Vegas plateau, the Llano Estacado, the bolson plains of central New Mexico and some of the less broken plains of eastern Arizona seem to belong genetically together. To the east and west a broad submarine platform was formed from the sediments derived from the planing off of the central land area. When the general bowing up of the region took place later in the Tertiary, the great plain formed was partly a peneplain of destructional land origin and partly a constructional plain of marine origin.

In the uprising, however, faulting took place on a large scale, giving rise to the numerous monoclinal block mountains in the region now within the boundaries of New Mexico. There were various halts in the general uprising tendencies and the Mesozoic and the youngest Paleozoic beds have been stripped off the mountain summits. Two or three times the staying process has enabled partial peneplanation to take place. But the mountain blocks have finally become tilted more and more.

Between Tertiary time and the present enormous erosion has taken place. The vast plain has been deeply dissected by such old mountain-born streams as the Canadian, Pecos, Rio Grande, and Colorado. The valleys of these water courses are very wide and deep. On the east the Canadian flows 4000 feet below the level of the old plain, the Pecos perhaps 2500 feet. The Rio Grande about 1500 feet. While the Colorado canyon is a mile deep.

In the Llano Estacado the remnant of the great plain contains 50,000 square miles. The bolsons are already beginning to give way to erosive agencies. In the valley of the Rio Grande nearly all traces of the old plain are already destroyed. The upland intermontane basins, like the Jornada del Muerto, which adjoin the long Rio Grande valley are being deeply dissected wherever the great river touches their borders.

New Mexico School of Mines, Socorro, July 30, 1903.

THE CLIFFWOOD CLAYS AND THE MATAWAN.

By G. N. Knapp, Trenton, N. J.

In the Bulletin of the N. Y. Botanical Garden, Vol. 3, No. 9, of Sept., 1903, there appears a paper by Edward Berry, on "The Flora of the Matawan Formation (Crosswicks clays)," in which the author after reviewing what has been written on the Matawan and Clay Marl and Raritan proceeds to describe the fossil plants found in the clays at Cliffwood, N. J., and to discuss their significance as a Matawan flora.

The stratigraphic relations of the Cliffwood clay have long been misunderstood, if indeed there has not been a serious error in their correlation.

In the light of the true relation of these Cliffwood clays to the Raritan and the Clay Marls the significance of this cliffwood flora assumes a very different meaning.

The following quotations from this paper show the author's conception of the stratigraphy:

"In its northern portion the Matawan is readily separable upon lithological grounds into Crosswicks clays and Hazlet sands."....

"In his report on the Surface Geology professor R. D. Salisbury states that his assistant, G. N. Knapp, distinguishes five layers' in the Clay Marl and traced them across the state.

"These he designates Merchantville bed (Marly clay), Woodbury bed (Dove-colored clay), Columbus bed (sand), Marshalltown bed (Marly-clay sand) and Wenonah bed (sand),"....

"These features, although more or less marked, are not sharply defined throughout the entire area of the Matawan, and professor Clark has never attempted to name or map any of the subdivisions other than the lower clay member"...."The Matawan is abundantly fossiliferous, especially along Crosswicks and Pensauken creeks. Clark enumerates eighty-six species of invertebrates, and Lewis Woolman....has added several others...."

"The exposure fronting on Raritan bay near Cliffwood, N. J., and forming a bluff some thirty feet high northwest of Matawan creek, has been admirably described by Hollick who records obscure Crustacean and Molluscan remains from which professor Whitfield identified eight species of mollusks, and enumerates twenty-six species of plants".... "I have found some few molluscan remains here, occurring in the ferruginous concretions picked up on the beach"...."the flora has more in common with the middle (Woodbridge) stage of the Raritan than with the other layers of that formation, eleven of the seventeen identical species occurring there".... "I am enabled to enumerate sixty-seven different species of plants of which fourteen are new,....nineteen are of doubtful affinities"...."Fifteen of the Matawan species are found in the Raritan of the islands, eight on Long island,....seven on Martha's Vineyard....nine on Staten island."

It is evident from these quotations and other statements in the paper that the author considers the entire cliff at Cliffwood one formation which yields a fauna like the Crosswicks clays fauna and the flora under consideration.

He regards the fauna and flora as belonging to Matawan, but recognizes that the fauna is like the Crosswicks clays fauna and the flora more like the Raritan flora.

One would think that such an assemblage would have suggested a closer study of the cliff to see if the fauna did not come from one horizon and the flora from another, in short to see if part of the cliff was not Clay Marl and part Raritan.

Apparently there was no attempt to verify the correctness of the correlation of the Cliffwood clays with the Matawan: it was taken for granted apparently that the whole was Matawan.

The author was no doubt warranted in this assumption since the Cliffwood clays have been definitely referred to the Matawan by professor Clark in the *Journal of Geol.*, Vol. 2, page 163, and also in the "Preliminary Geol. map" of the south shore of Raritan bay which accompanies the 1892 report of the N. J. G. S.

Now the stratigraphic relations are these: at Cliffwood is hill sixty-one feet A. T. according to the topographic atlas. On the northeast side a sea cliff is developing which has eaten back nearly to the center of the hill: so the top of the cliff is nearly sixty feet above tide. Capping this hill are six to ten feet of gravel of Pleistocene age.

Beneath the gravel is four to six feet of marly clay containing invertebrate fossils. Beneath this marly clay is forty feet or so of laminated sands and clays more or less lignitic.

The marly clay bed sandwiched in the hill top under the gravel is the basal part of the Merchantville formation the very base of the Clay Marls. This bed a few feet in thickness and a few rods in lateral extent is all the Clay Marl there is in this cliff. The thirty or forty feet of laminated sands and clays beneath and which appear at numerous points along the beach for three miles northwest to Chesequake creek are all Raritan.

The "ferruginous concretions" with fossils found on the beach were no doubt talus and came from the marly clay (Merchantville) at the top of the cliff. These concretions are just what one finds in the Merchantville everywhere all across the state.

The fauna from these concretions was like the "Crosswicks clays" fauna at Pensauken creek (Lenola): naturally it was since it is this same Merchantville bed at Lenola that yields the abundant fossils.

The flora no doubt came from the laminated sands and clays beneath the Merchantville, and was "more like the Raritan flora;" naturally since this sand is itself Raritan.

A stranger unfamiliar with the Clay Marls and Raritan might easily fail to recognize the Clay Marl-Raritan contact in the Cliffwood cliff, but any one who had traced this contact across the state from Penns Grove on the Delaware to Cliffwood on the Raritan would not fail to instantly recognize this contact in the Cliffwood cliff.

Moreover the region southwest of Cliffwood four to six miles is nearly bare Cretaceous and this contact can be traced across country with greatest ease. There is no mistaking it.

Stratigraphically there is only one horizon at which the Raritan-Clay Marly contact can be rationally drawn.

The Raritan is a very heterogeneous deposit lithologically; here it is a dense black fat clay, there it is a snow white high grade potters' clay, again it is a clean white quartz sand ninety-eight per cent silica, at another place it is a laminated sand and clay with logs of lignite and leaf beds and pyrite nodules galore.

The change in the Raritan from the one to the other of these types of material is strikingly sudden both laterally and vertically, so that along the strike at the Clay Marl contact the Raritan is here a black lignitic clay, there a white clean sand, here a white clay and there a gravel bed. Structurally, lithologically and physically the Raritan is very erratic.

In striking contrast with this is the Merchantville bed at the base of the Clay Marls and lying immediately upon the Raritan.

The Merchantville is everywhere the same, persistent, and monotonously uniform from Penns Grove to Cliffwood, always a marly clay or clayey marl. It was dug for fertilizer in a score of places in days gone by; *always* weathering in characteristic fashion. Always has the characteristic "ferruginous concretions" and so far as I have observed always fossiliferous.

This is the most sharply defined contact in the Cretaceous of New Jersey; and it is no doubt the most significant since it reflects the most radical change in conditions of sedimentation.

This is not saying that the Cliffwood clays are not Matawan but it is saying that they are not Clay Marl.

If the Matawan is the equivalent of the Clay Marl, if the base of the Clay Marl is the base of the Matawan, then the Cliffwood clays are not Matawan.

If the Cliffwood clays are Matawan then the Matawan disregards stratigraphy and groups a part of the Raritan with the Clay Marl. If the Matawan is a faunal name simply then such a grouping would be possible, but in that event the paleontological and paleobotanical evidence must needs be very weighty since such a grouping does violence to the stratigraphy.

There is no objection to making the Matawan include the Cliffwood clays so long as it is kept clearly in mind that the Cliffwood clays are Raritan. But the Cliffwood clays must not be spoken of as the equivalent of the Crosswicks clays and the flora of these laminated sands and clays at Cliffwood must not be confused with the fauna of the Crosswicks clays. And the fauna from the Merchantville marly clay at the top of the Cliffwood cliff must not be confused with the flora of the clays and sands beneath.

The clay report of the New Jersey geological survey, 1878, page 75, reads, "The green sand of the Clay Marl seen in the cuts of the N. Y. & Long Branch R. R. near Cliffwood road and station marks the southeastern limit and top of the plastic clay series (Raritan)."

A glance at the map shows that this throws all the Cliffwood clays into the Raritan and shows, when taken with the context, that the writer of the '78 report clearly recognized the Cliffwood clays and definitely referred them to the Raritan.

Faunas and floras are supposed to be aids to correlation: it might not be imperinent to inquire why the Cliffwood clays were not referred at once to the Raritan on paleobotanical evidence when sixty-four per cent of the species were identical with the Woodbridge flora and still others were identical with species found in the Raritan of Staten Island, Long Island. Block Island, and Martha's Vineyard.

It is disconcerting to the stratigraphist when the paleobotanist and paleontologist refuse to follow their own guides.

Trenton, N. J.

BITUMEN AND OIL ROCKS.

By G. C. Broadhead, Columbia, Mo.

Bituminous, or asphaltic, rocks owe their condition to the presence of the oil with which they are saturated. These oils are various forms of what is commonly called petroleum. Hydrocarbons include marsh gas, the light gases formed in mines and flowing from deep wells; thin oils, as petroleum, thick oils as maltha and bitumen or mineral tar, asphalt and the various coals. Where oil and tar springs prevail, the rocks are generally saturated with the oil and may be easily recognized by their odor or dark oily appearance.

Petroleum was known to exist in the Appalachian region in Pennsylvania and New York for more than one hundred years before its value as a source of heat or of light was recognized. At present it is obtained from wells in Canada, Pennsylvania, West Virginia, Ohio, Tennessee and Kentucky, where it first began to be used soon after 1860 A.D. It is also profitably obtained in Wyoming, Colorado, California, Kansas and Indian Territory, but is especially abundant in southern Texas.

Professor Hitchcock enumerates fourteen different geological formations from which petroleum has been found in the United States, and they include every geological age from the Lower Silurian to the Pliocene Tertiary. Limestones are sometimes saturated with petroleum, but more often sandstones. These, on account of their porous condition, may absorb and retain a large amount of oil.

In Pennsylvania oil is found in three principal sandstones. In Nova Scotia bitumen occurs in cavities lined with calcite. In Canada, large orthoceratites (of Trenton age) sometimes hold several ounces of petroleum in their cavities, and at Montmorenci it exudes in drops from the corals of the Birdseye limestone. The bituminous limestones of Chicago and also of western New York, when heated exude drops of bitumen. In Iowa, geodes of Keokuk age enclose bitumen. In Bates county, Missouri an Upper Carboniferous limestone, showing no oil on the surface, upon being broken, shows cavities in fossils where bitumen is found. Salt water was the precursor of the discovery of most of the Pennsylvania oil wells.

Theories Regarding Oil Formation.

Professor J. D. Dana supposed that oil has been formed through decomposition of animal and vegetable substances, that the oil-yielding rock was in a state of fine mud, that through this mud much vegetable and animal matter was distributed. This stratum was afterwards overlaid by other strata; the decomposition of the organic matter went on without the presence of the atmosphere; under such circumstances either vegetable or animal matter might be converted into oil.

It is thought by some that the oily product of certain rocks is of animal origin, and the evidence is, that fossil fish are almost the only fossils found in the Trias of the Connecticut valley. Fish remains are common in other oil-producing shales, as the black shales of Saarbruck, Prussia, Autun and near Clermont, France, and the Zechstein of Mansfeldt.

Professor Peckham regards all bitumens as having been originally derived from either animal or vegetable remains, but that the manner of their derivation has not been uniform.

Oils vary in density from the lightest naphtha, to thick viscid fluids, and pass by gradation into asphaltum and solid bitumen.

John F. Carll of Pennsylvania gave a general vertical section of over 600 feet from the top of the upper barren Coal Measures to the Corniferous inclusive, in which he defines four distinct oil rocks below the Carboniferous.

Dr. Ansted considered gas springs the product of the same kind of action that produced petroleum; and on observing gas discharges at Pescara, Italy, and in the Crimea, did not interpret the phenomena as volcanic, but as associated incidents of the dying out of the metamorphic action, which in most cases by invading strata containing organic matter, distilled all the forms of bitumen, including inflammable gas. In the Appalachians, the accumulations of gas are often found upon the anticlinals of the pebble conglomerates and sandstones that hold the petroleum, while at the lower level, in the troughs of the synclinals, salt water occurs; but there is no evidence of volcanic action. Professor Lesley concluded that gas is a direct product of petroleum by spontaneous evaporation. If so, the life of gas production will be limited by the amount of volatile elements held in a definitely limited quantity of petroleum existing under ground.

Asphaltum is regarded as the ultimate result of a series of changes which take place, under certain conditions, in organized matter, producing 1st, naphtha; 2d, petroleum; 3d, mineral tar; 4th, asphalt or hard bitumen. They merge into each other by insensible degrees, so that it is impossible to say when mineral tar ends and asphalt begins. Asphaltic stone is stone in which the substance will harden and it has become very valuable as a paving material. Gesner says that bitumens will yield a whole series of hydrocarbon oils.

It may be well here to quote from professor J. W. Dawson, who, speaking of waste macrospores, or larger spores of a species of cryptogamous plant being dispersed in countless millions of tons through shales of the Devonian of Canada, and the United States, refers these to rhizocarps. The walls or enclosing sacs of these macrospores, professor Dawson considers to have been of very dense consistency, appearing now as a highly bituminous substance agreeing with those of the spores of lycopods, and like them having been of a highly carbonaceous and hydrogenous quality, very combustible and readily admitting of change into bituminous matter; from this composition it is readily concluded that such spores are admirably suited for the production of highly carbonaceous or bituminous coal. The remarkable uniformity of structure and form of those bodies over great areas, combined with the great thickness of the rocks containing them, and the absence of any other kind of spore case make a striking coincidence. The true sporangites are round and smooth with thick bituminous walls which are punctured with minute transverse pores. The black shale of Ohio and similar shales of the same geological age (Devonian) in Brazil also abound in like organisms. Similar forms also occur in the white coal of Australia and Tasmania.

Bituminous Rocks in Missouri.

Bitumen occurs in western Missouri from Caldwell county on the north to Newton county, a distance of 175 miles north and south, and a width of from 25 to 40 miles east and west. It has been found in ten counties of Missouri, the rocks apparently becoming more bituminous in their southern extension. From Cass county southwardly, and extending into Kansas, tar springs are of frequent occurrence. Although the rocks often appear black and oily drops are seen oozing out, and pools of tar are formed, still the amount does not seem to be concentrated in quantity sufficient to pay for the working. Its mere presence has occasioned the sinking of several deep wells with no profitable result. There are no positive anticlinals nor synclinals in this district. Its greatest vertical extent is 600 feet and averages 300, lying chiefly in the lower Coal Measures although it is found in sandstone just below the upper Coal Measures. It is also found in the Lower Carboniferous limestone of southwest Missouri. Nearly all of the coal and many of the rocks of the southwest when freshly broken, emit an odor of oil. Free bitumen from Ononogo, Jasper county, gave bitumen 95.75 per cent, ash (pale yellow) 4.25. Bitumen mixed with sand, from Barton county, gave bitumen 44.74, ash 55.26.

Prospecting for Oil.

Between 1864 and 1868 several deep wells were bored for oil in western Missouri with no profitable result, although rocks containing oil are of frequent occurrence.

On the MacCausland farm, near Higginsville, in Lafayette county, there is an extensive exposure of sandstone mostly black and quite sticky with bitumen. This attracted speculators soon after the first excitement in Pennsylvania, and about 1865 a well was bored over 700 feet deep, showing no downward increase in the amount of oil. The sandstone here belongs to the age of the lower Coal Measures.

About the same time a well was bored over 700 feet deep on Mormon Fork, in Bates county, in search of oil. All the oil at this place was contained in about thirty feet of sandstone at the surface. On Fishing river, in Ray county, some bitumen appearing in the surface sandstone caused a boring of over 800 feet to be made, but no oil was found below.

In boring at the foot of the bluffs in Kansas City, in 1872, bitumen was encountered at 180 and at 291 feet, and it was reported to flow to the surface. Gas escaped from 450 feet. A well was drilled at St. James Hotel, Kansas City, and oil and gas were both obtained at 245 feet, and also at 300 feet in sandstone, and again at 313, and gas at 345 feet. At Dr. Ridge's well, Kansas City, gas was found at 282, 371 and at 398 feet and was used for illuminating purposes..

At the foot of the bluffs, Randolph, Clay county, two borings were made, one of 690 feet the other 848 feet. The surface at these wells is at about the base of limestone No. 78 of my section of the upper Coal Measures, or just below the base of the upper Coal Measures. One well passed through the Coal Measures at 671 feet, the other a little deeper. No gas was observed, but between 118 and 133 feet petroleum prevailed, deeply coloring the sandstone. The oil here, also in Kansas City, at the Mormon fork well, and that on Fishing river, occurs in each instance in a sandstone of the same geological age, just below the base of the upper Coal Measures.

Tar springs occur near Rich hill and southwardly in Vernon and Barton. Miners in Jasper county pick the tar from the ore and chew it like gum.

The bituminous sandstones of southwest Missouri seem to have been rendered tougher by the presence of bitumen, and while we do not consider that there is oil sufficient in Missouri to search for, yet these rocks may become valuable as a paving material.

Oil Zones.

In America, bitumen occurs along a zone extending from Point Gaspe, Canada, to Nashville, Tennessee, and under an area, in the United States of more than 3100 square miles; also from lake Athabasca, southwardly through Nebraska, Kansas, Missouri, Indian Territory and Texas, being especially abundant in the northern and southern extension. It is found along the Mexican coast, and in Wyoming and Colorado on the east side of the Rocky mountains. In California it is well known from San Francisco to San Diego. It occurs from Havana, Cuba, through San Domingo, the Leeward and Windward islands to Trinidad, thence to Magdalena, South America, and to Cape Blanco, Peru; along the Rhine valley and the Rhone; along the Apennines to southern Sicily, and east to the Adriatic; from Spain through Switzerland, the Balkans, Palestine and eastwardly; from Hanover on the North sea through Gallicia, the Caucasus and the Punjaub; from west China through Burmah to Sumatra and Java; in Japan, and along the Australian coast.

Most of these oil zones are intimately connected with the direction of the chief mountain ranges of the world, and seem to be, apparently, along certain lines of weakness in the earth's crust.

Some Remarkable Oil Districts.

In the eastern part of Kansas there are many gas wells, and but few strong oil wells. Wonderful gas flows have been known at Fort Scott, Ossawattomie, and Iola, some also at Kansas City, Kansas, at Ellsworth, Emporia, Paola and Lewisburgh. Gas wells also occur in Indiana, Ohio and the Appalachian region, especially in the oil regions. The most prolific oil springs were on Oil creek, Pennsylvania and here in 1859 were the first borings for oil. The Phillips well produced 3000 barrels per day, but by 1864 the production had declined. The greatest oil flows in America have been at Beaumont, Texas, where a six inch stream spouted up 120 feet in the air. The gas pressure here is very great. The Lucas well was estimated to flow 70,000 barrels in twenty-four hours. The oils here probably flow from the Lower Tertiary. Northwardly, at Corsicana, oil flows from the Cretaceous.

An asphaltic limestone from Ardmore, Indian Territory, has been quarried for paving purposes. It is rich in cephalopod fossils. A peculiar asphalt which has been termed gilsonite is quarried in Utah. Albertite resembles asphalt. It is brittle, black and lustrous, with a broad conchoidal fracture, but it differs from it in fusibility and its relation to various solvents. It does not melt like asphalt, but can be melted in a closed tube. It is found in New Brunswick in calcareo-bituminous shales which contain fossil fish, and occupy an inclined vein. Grahamite, found in Richie county, West Virginia, resumbles albertite.

A well in Knox county, Ohio, affords 10,000 barrels of water per day and through this water gas shoots up nearly seventy feet above.

There is a bituminous lake near the Bay of Campeachy in Mexico, around which there is a solid black shining crust, while towards the centre it is soft and in some places the bitumen boils up as if in a constant state of ebullition, sometimes bubbling up in cones three or four feet high, which evolve vapors, burst and overflow. At rare intervals the lake becomes ignited and the whole surface is covered with a sheet of flame.

A wonderful lake is that of LaBraye, on the island of Trinidad, one and a half miles in circuit. It is hot at the centre, but solid and cold toward the shore. Its borders are covered with hardened pitch on which soil has accumulated and trees flourish. There are said to be occasional pools of water in which fish live. It is also said that the odor from the lake can be detected eight miles off.

A valuable bituminous rock found at Val de Travers, Switzerland, has been extensively used as a paving material.

Elaterite, or elastic bitumen, is found in south Australia.

Baker on the Caspian sea has been celebrated for ages for its ever-burning naphtha springs. Those on the shore have long been attended by the fire-worshippers from India. Oil also rises from beneath the sea to the surface. Some wells have produced as much as 100,000 barrels a day. From some of these have flowed great showers of naphtha.

Bitumen in Ancient Time.

Far back in the remote uncertainty of time, we find that, in building the tower of Babel, "slime had they for mortar," that the ark of Noah was coated within and without with pitch; also that the mother of Moses "took for him an ark of bulrushes, and daubed it with slime and with pitch. Herodotus* informs us that the walls of Babylon were of brick, laid in bitumen. It was heated and used as a cement instead of mortar. Herodotus also says that it was mixed with the tops of reeds, and placed between the bricks at every thirteenth course. Some travelers say that they have found bitumen used in every seventh or eighth course, and at one place was found between every two courses of brick. Some bricks were laid in lime and sand, or only clay, others in bitumen.

Bricks from Hillah, with bitumen still adhering to one side, were examined by Parkinson about the beginning of the nineteenth century, and the bitumen was found to be still combustible, and would burn when brought into the flame of a candle, yielding a strong bituminous odor. The village of Hillah, or Hellah, is said to occupy the site of the ancient tower of Babylon, and the city of Babylon must have been on or near the present site of Hillah, which is known to have been built of the bricks of the ancient city, and it even may have been built upon the very site of ancient Babylon. The bricks examined by Parkinson, must, therefore, have been at least 3500, or perhaps 4000 years old.

Bitumen flows out of the ground at Babylon. It is also dug up in Syria; but that used at Babylon was obtained at Hit or It, or on the river Is, of Herodotus, eight days journey above Babylon.

* In Clio.

The wall of Medea, between the Tigris and Euphrates was built of burnt brick laid in bitumen. We are also informed that the Persians would dip their arrows in pitch, light them, and shoot upon the roofs of their enemies' houses.

The Dead sea, or lake Asphaltites, is mentioned by most of the ancient writers as being very bituminous, and Diodorus states that near its middle a mass of bitumen would rise up every year and float off, appearing in the distance like an island. This was gathered, taken off and sold to the Egyptians who used it in embalming their dead.

In modern times the Arabs procure the bitumen from the shores of the Dead sea, and sell it to distant people.

Bitumen is spoken of by some of the ancient writers as pissasphaltum, and at Agrigentum it was burned in lamps in place of oil, and called Sicilian oil.

The oil from Baker is much valued for making steam. The Texas oils are also much valued for both light and heat.

THE NEWLY DISCOVERED ROCK AT SIOUX FALLS, SOUTH DAKOTA.

By J. E. Todd, Vermilion, S. Dak.

The recent discovery of a dark granite, or gabbro, near Sioux Falls, has not yet been recorded in scientific journals. It is more truly a granite than the rock from that locality so called in popular prints and even in the reports on Mineral Resources published by the U. S. Geological Survey.

It is rather remarkable that it should escape discovery so long in the vicinity of a metropolis specially interested in stone quarries. It had in fact been recognized as different from the common rock of the region some fifteen years ago by two or three workmen of stone, but not having the means to develop it they had discreetly held their tongues concerning it. Only a few square yards had been exposed in the bed of a small tributary of the Big Sioux, until the unusual rains of this season had cleared out the channel of the brook more thoroughly. The Williams brothers and Mons Blum, then fearing that their secret was in danger, put in a blast and obtained a block which they polished and exhibited to some of the prominent business men of the city. Samples were sent to the U. S. Department of Agriculture, the National Museum, the state geologist and the State Agricultural College. All gave favorable opinions of its probable value for ornamental and monumental purposes.

Dr. Geo. P. Merril, head curator of department of geology in the National Museum, says: "The sample of rock forwarded belongs to the basic igneous class, commonly known as gabbro. In general appearance this rock bears a close resemblance to the gabbro quarried near Addison, Maine, and commercially known under the name of black granite. The mineral constituents of this rock are plagioclase feldspars, augite, biotite, and magnetite or titanic iron, together with microscopic apatites. In this respect it differs somewhat from the Addison stone, which carries also the minerals hypersthene and olivine. The Quincy, Barre, and St. Cloud granites differ from the sample submitted, in that they all carry orthoclase feldspars and free quartz.

"As to the weathering of this particular sample forwarded, I cannot speak too definitely from a mere inspection of the sample. Rocks of this class vary greatly in their weathering properties. The Addison, Maine, rock which it closely resembles, has been found by experience to be exceedingly durable and in all respects a most excellent stone. I am not quite so favorably impressed with the sample you forward, owing to its great richness in magnetite, which while not at all injurious in small quantities, may prove so where existing so abundantly. I might suggest the best method in your locality would be to inspect natural outcrops, and particularly the glaciated surfaces, if such exist. If the rock, where it has been exposed to the action of the atmosphere since the passage of the ice-sheet, still shows glacial polishing and striæ without serious discoloration, it is pretty good indication that the stone will be suitable for all human requirements."

Secretary Wilson of the Department of Agriculture having submitted it to the chemist of the department, reports: "The rock is commonly known as trap, and scientifically as diabase. It is composed essentially of feldspar (labradorite) and augite, and contains about ten per cent iron ore (magnetite) which is the cause of the rock rusting on exposed surfaces. The rock is of igneous origin and occurs usually in large masses, reasonably free from cracks and seams, but containing joint planes which facilitate the quarrying of large blocks."

"Similar rock is quarried at Addison Point and elsewhere in Maine, and is locally known as black granite. It is used wholly for monumental purposes."

Professor Jas. H. Shepard of the S. D. Agricultural College, writes: "I am in receipt of your esteemed favor and also of the beautiful sample of black granite you sent me. I tested this sample with the most corrosive agents in my laboratory and find they have little or no effect upon it. This indicates that it will be valuable for ornamental and monumental purposes. Personally I think the sample a fine one and if you can quarry it in blocks sufficiently large it will have a commercial value of no small proportions."

To ascertain as far as possible the geological relations of the rock and to learn of its weathering properties from an inspection of its outcrops, the writer visited the locality not long since.

The rock was first discovered on land now owned by Brown, Ross and Lyon, in the southwest of the northwest quarter of section 11, 101, 49, about two miles northeast of Sioux Falls, and it was found to extend also on to the next quarter west, owned by Mr. B. H. Lien, who has done the most in developing it. An exposure is also reported as occurring in the bed of the Big Sioux about a quarter of a mile further west, but not accessible at the time of my visit. Boulders identical with this rock are said to have been found a little north of Brandon, but it is quite different from the igneous rock exposed on the Split Rock a little north of Corson and described by Culver,* Hobbs and Beyer.† The boulders near Brandon may possibly have been transported from the locality discovered.

The exposures under consideration are only a few rods from the Big Sioux and their highest point rises only about ten feet above the waters of that stream. About an acre is now exposed and by probing it is known to extend much farther at lower levels, covered by only a few feet of loose earth. No exposures of Sioux quartzyte are known nearer the gab-

* *Trans. Wis Acad. Sci.*, vol. viii, p. 206, 1892, and *Bulletin 1, S. D. Geol. Survey*, p. 36, 1894.
† *Iowa Geol. Survey*, vol. vi, p. 79, 1898.

bro exposure than about half a mile; therefore the relation between the two rocks has not been demonstrated. Laborious and expensive borings would be necessary to do so. There can be little doubt, however, that the gabbro is an eruptive later than the quartzyte like the olivine diabase near Corson and a rock struck near Dover,* 500 feet down, which is much like the latter, a green eruptive struck at Yankton† at 880 feet and penetrated 49 feet, and a quartz-porphyry found at Hull, Iowa.‡

The rock is remarkably uniform in character, there being no blotching nor difference in size or arrangement of grains on different sides of a block or in blocks from different points. The grains are rarely over an eighth of an inch across. The combination of the black augite and magnetite with the pearl gray plagioclase is suggestive of delicate foliage showing clusters and branches. Quartz is absent and biotite is not evident. It takes a beautiful polish. The whole surface is lustrous, though the magnetite shows a duller metallic sheen, which gives another pleasing contrast. The writer failed to find trace of titanium, as Merrill reported, but can corroborate his other statements.

From the abundance of iron present it has been feared that the rock would rust and disintegrate readily on exposure to weather, but the appearance of the natural exposures seems to demonstrate the very opposite. No glaciated surfaces were found; the rock was probably too low below surrounding exposures to be strongly rasped by the ice, if touched at all. But the rock where exposed naturally near a small stream has a grayish appearance with some rust, and the weathered cortex is very thin, less than a sixteenth of an inch, and of very even thickness, its inner surface merging abruptly into rock as black and firm as that many inches below. All grains seem to have similar resisting power; none seem to invite disintegration by absorbing corrosive elements. Where the rock has been covered with a few feet of porous silts and gravels, so that air and moisture have had most favorable opportunity for corroding, the weathered shell is rarely over half an inch thick and has the uniform thickness and abrupt change below as in

* *Bulletin 2, S. D Geol. Survey*, p. 98.
† *Ibid.*, p. 101, 1898.
‡ *Iowa Geol. Survey*, vol. i, p. 165, 1892.

the other case. The length of time which these conditions have continued is somewhat uncertain. Certainly not for the whole time since the glacial epoch, but probably for centuries. Evidently such a test would be more severe than any to which it would be subjected in human requirements.

A dark gabbro near the Lake of the Woods is so magnetized that a magnetic needle, carried in the hand over its surface a few yards, will swing through 180°, but no such polarization of this rock could be detected.

It resembles closely the Addison stone already mentioned, in composition, color and lustre when polished. It is not quite so dark, has larger grains and the magnetite is a little more conspicuous. That is a very durable rock. Enough exploitation has been done to show that blocks of any size desired may be obtained.

It may confidently be expected that the stone will become a favorite when its excellencies are known.

EVIDENCES OF RHEUMATOID ARTHRITIS IN THE LANSING MAN.*

By Charles A. Parker, Chicago, Ill.

Although the skeleton is incomplete, yet the articular surfaces of all the larger joints as the shoulder, elbow and wrist, hip, knee and ankle are sufficiently well preserved to allow of definite statements regarding evidences of former disease in them. Evidences of rheumatoid arthritis, or arthritis deformans, are found in the bodies of the lumbar vertebrae, the head of the metatarsal bone of the right great toe, and the articular surfaces of the femur and tibia of the right knee-joint.

*Through the kindness of professor Haworth, the skeleton of the 'Lansing Man,' now preserved in the museum of the University of Kansas, has been submitted to me for further examination. After considerable reparation the bones were submitted ot Dr. Parker, through the kindness of Dr. Hektoen, for study, and his report upon them is here published in connection with the literature upon this subject which has already appeared in these pages. My early statements concerning the skeleton were based upon an examination made while the bones were yet unmended, and largely concealed in the original matrix, which at that time it was not thought prudent to remove. I quite agree with Dr. Parker's determination of the sex. S. W. Williston.

The heads of the two radii, although showing none of the excrescences or eburnations of rheumatoid arthritis are noticeably flattened and expanded, presenting the appearance of a large head on a small nail. The disparity between the heads and necks is also shown by their measurements when compared with other bones. Thus while the average relation between these two parts is as 24 to 15, or as 8 to 5, the necks of these two radii measuring but 11 mm. in diameter support heads of 22 mm. or twice their size. The margins of the acetabulum are sinuously curved but present no excrescences or erosions.

The characteristic changes in detail are as follows: Parts of the bodies of two lumbar vertebrae show considerable flanging or expansion at their articular borders but no evidence of anchylosis. The several articular processes show no evidence of disease. The few remaining bodies of the dorsal vertebrae are also free from disease. The articular surface of the head of the metatarsal bone of the right great toe is prolonged backward, below. Slight lateral excrescences more distinct on the outer surface, are present along its margins. The middle convex ridge is eburnated below.

The knee-joint: The external condyle of the femur presents a reflected flange of bone 4 to 8 mm. wide along its outer margin corresponding with a similar though somewhat more luxuriant outgrowth from the same margin of the external articular surface of the tibia. A distinct irregularity is also present at the posterior termination of the articular surface over which the tendon of the inner head of the gastrocnemius normally glides. The irregularity consists in a slight exuberance of bone at the upper margin with a distinct erosion and flattening of the articular portion.

The surface is so irregular that definite lines of attrition, as presented in other portions of the surface can not be made out. It may possibly have been due to the presence of a sesamoid bone in the tendon of the gastrocnemius, though an apparently reciprocal surface near the posterior margin of the articular facet of the tibia, offers the more probable explanation of its occurrence.

At the juncture of the middle and posterior thirds of the articular surface, or at the place of bearing in semiflexion of the knee, is an area 2 cm. long and extending practically the width of the condyle showing the typical eburnation of rheumatoid arthritis with the characteristic striae extending antero-posteriorly in the direction of motion and attrition. The striae average a little more than a millimetre apart, and are reciprocal with similar ones on the upper surface of the tibia, the slight elevations of one fitting into the corresponding depressions of the other. They are distinctly shown in the accompanying photograph. The articular surface and margin of the internal condyle show no pathological changes.

The outer tuberosity of the tibia shows a reflected flange of bone one cm. wide at its posterior part and apparently less developed near the front, although its incomplete condition there does not admit of a positive statement of its previous condition. A small tubercular excrescence is also developed on the outer tubercle of the spinous process (tuberculum intercondyloideum laterale). On the articular surface, besides the polished and flattened surface near the posterior and inner margin considered above as reciprocal to a similar surface at the posterior extremity of the articular surface on the femur, is a pear-shaped arosion at the juncture of the middle and posterior thirds with its larger part externally and narrow stem extending internally.

This area measures 1.5 cm. antero-posteriorly in its broadest part and extends transversely completely across the face of the facet. At its deepest part it is 1 mm. below the joint level. Its longitudinal striae already mentioned are very distinct and correspond with those described on the lower end of the femur and shown in the same figure.

The internal tuberosity and articular surface are missing. They would probably show no changes, as there are none on the corresponding internal condyle of the femur. The patella is normal.

The few slight changes thus considered as due to rheumatoid arthritis are such as are frequently seen in the bones of old people, and are of such limited extent that outside of an occasional "rheumatic" pain in the knee-joint or unpleasant twinge of the great toe, they probably offered very little or no inconvenience to the original possessor.

In an article in the Popular Science Monthly of March, 1903, Prof. Williston speaks of the skeleton as presumably—I think he used that term—that of a woman. There is no better evidence than the pelvic bones, and as the symphysis pubis and part of one descending ramus and all of the other are present, the subpubic angle is readily determined to be decidedly acute, or of the male type, and entirely lacking the obtuse or rounded character so distinctive of the female.

Rush Medical College, Chicago, Dec. 16, 1903.

EDITORIAL COMMENT.

DIRECTION OF PREGLACIAL STREAM-FLOW IN CENTRAL NEW YORK.

In the March number of the *Journal of Geography* is an article by Mr. Frank Carney entitled, "A Type Case in Diversion of Drainage," which contains an error that should not be allowed to pass uncorrected.

The author makes the valley of Fall creek at Ithaca the lower course of a preglacial river, a trunk stream, draining a large territory on the east and northeast, and debouching into the Cayuga valley by the present Fall creek channel. One principle and one fact will together be sufficient to show the impossibility of the postulate, and that no considerable preglacial stream could possibly have followed the course given in his map.

One of the elementary principles of the modern science of fluviology is that a vigorous stream will in time grade its channel consonant to its baselevel, whether that baselevel be another stream or static water. Certainly the millions of preglacial years gave the suppositious Fall creek river all the time it needed to produce full gradation. It could not possibly have retained in its path any cataract or cascade or even rapids, and it would have opened a broad valley, graded of necessity to the Cayuga valley. This would be equally true whether it was tributary to another stream in the Cayuga valley or was itself the main stream. But now as a matter of simple fact there is no such tributary valley joining the Cayuga valley at Ithaca. Fall creek today plunges down a rock slope several hundred feet to reach the Cayuga level, and is evidently in a postglacial gorge. Nor is there any buried nor any deserted valley which could have been the product of the hypothetical stream.

It might be claimed that the gradation plane of the hypothetical river is above the Cornell University level, in the open section of the Fall creek valley, at about the 1100 foot contour. But this would require a glacial or postglacial excavation of Cayuga valley of a thousand feet. Even the most extreme advocates of great glacial erosion will hardly venture to make that claim.

The only conclusion is that the hypothetical river did not exist. The error is partly due to reliance on surficial maps and to ignoring the rock geology. It illustrates the truth that geography must be based on geology. The complicated problem here raised can not be fully solved by any study of stream directions and present contours on topographic maps. The modern topography and the present trend of valleys and drainage may suggest certain directions of ancient stream-flow, and may properly form a basis for a working hypothesis, if not contradicted by other facts. But the basal facts to which all theories of ancient stream-flow must yield are those relating to the hard-rock topography, or the old valley forms with the drift-filling ignored. Until borings in the valleys in question have been made in number sufficient to determine rock altitudes of critical points and the slopes of the rock valleys the true direction of the preglacial drainage must remain in question. However, the non-existence of an ancient valley at Ithaca, from the northeast, can not be in question.

Another factor which should be considered, although it may not be of importance in this case, is the preglacial, differential, northward uplift. In the district of Cayuga and Seneca valleys this uplift is probably not less than two or three feet to the mile; which is a far greater slope than the gradient of mature streams of large size.

The remarkable rhomboidal forms of the gross topography between the meridians of Ithaca and Cazenovia present an interesting problem, but much more complicated than it might appear. There is a large element of stratigraphical geology involved, along with preglacial epeirogenic movements. By way of stimulating investigation the writer will venture the following prediction. (1). That borings will show, in general, relatively shallow drift in the northeast-southwest valleys, which implies that these broad valleys were the product of weathering along the strike of the strata, with some early work of beheaded or diverted streams. In other words, these valleys were cols between deeper valleys. (2). That the main drainage of the area, preceding the ice invasion, was northward by several parallel valleys, of which the present broad areas at Freeville and Cortland are open sections. These north-leading valleys were subsequent to the greater east-west Ontario valley, and belonged to the series of north-sloping valleys of which Seneca and Cayuga are the conspicuous members. (3). The largest of the eastern streams probably occupied the Onondaga valley, in the upper buried part of which lie the villages of Tully, Homer and Cortland. Freeville lies in the upper, buried section of the Otisco valley.

Incidentally it should be said that it is extremely improbable that any large stream would develop such a direct course, oblique to the dip of the strata, as Mr. Carney depicts in his hypothetical map at the close of his article. And the reference to the "moraine of the second glacial epoch" is untimely since the moraine in discussion belongs to the "Wisconsin" epoch, now regarded as at least the fifth epoch of glaciation.

H. L. F.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Revision of the Blastoidea, with a Proposed New Classification, and Description of New Species; by G. HAMBACH. (Tran. Acad. Sci. St. Louis, Vol. I, No. 1, at pp., St. Louis, 1903.)

A long needed review of the American species of blastoids has finally been issued. Dr. Hambach, who probably has by far the finest collection of material in the world for systematic, morphological and paleontological study, is to be warmly congratulated for his efforts in giving to students of this subject the benefits of his studies which have gone on without serious interruption for fifty years.

"The present revision and the anatomical descriptions herein given are based mainly on Pentremites sulcatus, P. florealis and P. conoideus, not because they are more abundantly represented than other species (for Pentremites godoni occurs in great numbers in Pulaski Co., Kentucky, as well as at Huntsville, Alabama), but the preservation of Pentremities sulcatus is so excellent that we often find the most delicate and fragile organs preserved, especially in those specimens which were imbedded in a kind of clayey substance. I think it is not unreasonable to suppose that similar conditions in structure must have existed in other species belonging to this family."

The structural elements are fully described in all their various aspects and the history of opinion briefly stated. An especially interesting discovery is a plated tube projecting above the calyx of the blastoid and corresponding to the anal tube so conspicuous in camarate crinoids.

"We find on the posterior side above the anal opening, on very well preserved specimens, a small proboscis about one-fourth of an inch in length, constructed of small hexagonal pieces. To my knowledge it is the first time that such a body has been observed on a blastoid. I found this appendix on Pentremites conoideus and have now four specimens of it showing this, so far unknown, organ. All four specimens are in an excellent state of preservation and show also the pinnulæ preserved. I am inclined to believe that similar organs existed in all typical species."

Regarding the proposed new classification, Dr. Hambach says: "The classification here offered is based mainly on the construction of the summit openings, because they exhibit a uniformity in structure, remaining always the same in their respective genera—a fact which must be of great value for classification. Next, the development of the deltoids is considered, also the aspect of the outer surface (whether smooth of spiny). Whereas the general size and shape of the body, whether globose, pyriform, ovoidal, conical or clavate, depends upon the variations in the form of the parts which construct the body, and whereas the relations of these parts to each other remain the same throughout the whole class, the difference can be only specific and not generic. Nor can we attribute any more than specific value to the hydrospiric tubes, or plications, on account of the variability often observed in one and the same specimen—a fact sufficiently recognized by the very authors who regard them as being of importance for classification. All names ending in 'crinus' are omitted.

"I also wish to remark that this classification embraces only our American species, although most of the European species, I believe (judging from my small collection of European specimens), will fit into one or another of these genera, with the exception of abberrant forms, like some of our American ones, of which it is still doubtful whether they should be regarded as blastoids of cystoids, for the reception of which a separate class should be established. This class may include all doubtful specimens and those insufficiently described and doubtfully illustrated because of the fragmentary condition of the material."

Students of exact systematic nomenclature will seriously object to the attempt to throw out all blastoid names ending in "crinus," as Granatocrinus for example, and the substitution of new generic names, and it is not probable that any paleontologist will be inclined to follow the proposition.

It would appear also that too many species have been recognized, but as this is merely a matter of personal judgment at best there can be little fault found on this score. It would have been a valuable and convenient addition to the memoir if all the specific bibliographic references had been given. However, this little monograph represents too many good results to permit any shortcomings of this nature to detract materially from its real worth.

In respect to the material upon which the studies were based, Dr. Hambach remarks: "Induced by the sweeping statement of Mr. F. A. Bäther, I give the following list, comparing the blastoids in my collection with those of the British Museum. According to Mr. Bather's statement, p.x., introduction to his catalogue, the collection contained then (1899) 1,223 specimens. Quoting his remarks: 'These figures speak for themselves. However numerous may be the specimens of Blastoidea in other museums, there can scarcely be any collection so representative of the class as a whole or as rich in specimens of the highest scientific importance as is that of the British Museum.' This is a strong expression, especially since Mr. Bather has not seen all collections. Considering that America contains the bulk of the material, although admitting that the British Museum has the very valuable collections of Gilbertson, I. Rofe and L. G. de Koninck of unique specimens, I venture to say that our American materal is on the whole better preserved than that found in Europe, and being confident that the American collectors did not send their best specimens across the water, it is not very doubtful to say that, for the study of this particular class of fossils, the best material is found on this side of the water. Comparing the figures of the British collection with my own, shows at a glance on which side the most material is to be found. Aside from this, my collection, which was brought together in fifty years, and comprises about ten thousand specimens, contains a number of real scientific specimens (pathologic and abnormal developments and specimens illustrating morphology) hardly to be found in any other collection. A student could learn more on a dozen or two picked specimens from our material than from the whole collection of Gilbertson, Rofe or de Koninck. Besides specimens illustrating the morphology, my collection contains considerably over one hundred pathologic and abnormal specimens."

The memoir is admirably illustrated by lithographic plates.

C. R. K.

Memoir 6, New York State Museum is entitled *The Naples Fauna in Western New York, part 2* (part 1 having been published in the 16th ann. rept. N. Y. State Geologist, 1898), quarto, 207 p., 20 photogravure plates, by John M. Clarke.

This work continues and completes the treatment of this remarkable fauna which at the commencement of the studies was known by only a few species, while as now tabulated its members rise to the respectable number of 170 species. The lamellibranchs (upward of 70 species) gastropods and pteropods are here treated in detail and some notes are given on other species of the fauna.

In the introductory chapter on *The sea of Portage time* is brought together a general summary of the results in their bearing on the bionomy of the fauna and their interpretation of the marine conditions of the period. It is shown that the fauna, invading from the west, entered the area of western New York or Genesee Province in processional succession, the advance penetrating in its integrity not farther than Cayuga lake, the rear battalion differing from its antecedent in many palpable particulars, entering to, but hardly beyond the meridian of the Genesee river. The presence of these two sub-faunas is shown to be in part vertically sequential and partly contemporaneous. With the evidence of these differences in faunal composition the entire or

Genesee province is divided into an eastern or Naples subprovince and a western or Chatauqua subprovince. The nature of the gulf in which this fauna flourished, its boundaries and connection with the sea, the origin and direction of migration of the fauna are fully discussed. Following the technical description of the fauna is a discussion of the relations of the congeries to other manifestations of the Intumescens zone, and a noteworthy fact here brought out is the actual appearance in New York of a large number of species indicial of this horizon elsewhere, especially in Westphalia and Timan, and the much larger series of close relationships between the New York and Eurasian species. The author's conclusions as to the significance of the fauna, derived from this protracted and exhaustive study, are given in the "summary" as follows:

"1. The fauna of the *Naples beds,* as the term has been heretofore employed and as used in the title of this work, is a congeries integrated by its organic characters and its bionomic relations from appearance to vanishment and unitive in its essentiality. With contemporaneous faunas of the Appalachian gulf it has, in its purity, no organic relation direct or sequential, but at the boundaries of the province may become implicated with the latter by the incident of geographic continuity.

"2. This Naples fauna as a whole is geographically characterized with greater accuracy as that of the *Genesee province.* In its integrity it represents the Eurasian Upper Devonic faunas above the horizon of *Hypothyris cuboides* (Tully limestone of New York) and below the brachiopod fauna with culminating *Spirifer disjunctus.* In the New York sections, however, it is followed by and is, in part, contemporaneous with a tremendous development of the brachiopod fauna, which is equivalent in sequence and in composition to that of the Condroz and Famenne sands of Belgium, etc.

"3. The geographic subdivision of this integral into (1) the Naples and (2) Chautauqua subprovinces, determinates: (a) the early arrival of the lower fauna in the Genesee province, its primary occupancy of the entire area, its eventual profuse development at the eastern end of the province till the incoming of the brachiopod fauna from the east; (*b*) the subsequent arrival of the organic assemblage which more fully exemplifies the later stages of the Eurasian fauna, stratigraphically sequential to the feeble western development of its predecessor, profuse in its own development in its proper province, but unable to penetrate the province of its antecursor, consubstantial and contemporaneous with it during all its own stages, but during the later stages only of the antecedent fauna.

"4. The fauna in its entirety shows a subversion of the facial differentials distinguishing its European phases, and species there recognized as successional indexes are here disvalued (*Clymenia, Entomis serratostriata, Chiloceras*). On the other hand, entire convergence of faunal differentials is not effected, and certain indexes retain their value in both lower and higher components of the fauna.

"5. In terms of paleontology, the fauna as a whole is the Intumescens fauna, for it is permeated throughout, in the development of both of its geographic elements, with goniatites of the type of *Manticoceras intumescens* and their normal accompaniments.

"6. The uniformity of expression of the fauna as a whole throughout its world-wide manifestation is its most noteworthy character and is without parallel.

"7. By the letting down of the old Mississippian land barrier, which guided the Middle Devonic (Hamilton) fauna from the far south into the Appalachian gulf, the Intumescens fauna entered this region from the northwest, and the proximal part of the path of its migration lies buried beneath Lake Erie."

The Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California, by RALPH ARNOLD. (Mem. California Acad. Sci., Vol. III, June, 1903.)

This monograph of the faunas of these later Tertiary beds of the California coast is based upon a large mass of material and is well wrought out.

The interest to the general paleontologist is found in the conclusions drawn by the author from comparison of the faunas with living faunas along the Pacific coast and with each other.

The horizons recognized are the *Merced series,* mostly Pliocene, and the *lower* and the *upper San Pedro* of Pleistocene age:

From the Pliocene beds 87 species were obtained; of these 63.1 per cent are now living on the coast of San Pedro. Of the whole fauna 18.5 per cent are species now living only north of San Pedro, and none are now found south of this point.

287 species are reported from the lower San Pedro beds Pleistocene, Of these 64 per cent are living at San Pedro, 17.4 per cent only, north, and 3.2 per cent only, south of San Pedro.

Of the 252 species obtained from the upper San Pedro beds 68.2 per cent are living, 6.1 per cent live only north and 14.2 per cent only south of San Pedro. The author concludes from these facts that the climate has been changing from Pliocene to the present time, and that it was much colder than now during later Pliocene time along the coast of California. In Pleistocene time the tropical climatic conditions advanced northward, until in later Pleistocene the climate was more tropical at San Pedro than at present, though not extremely tropical.

The author describes (and figures many of them) 408 species; some excellent reproductions of photographic views of the beds and coast are given. The work was executed under the supervision of professor J. P. Smith of Leland Stanford University, and does credit both to the author and the planner of the investigation. H. S. W.

Geological Results of the Study of the Tertiary Fauna of Florida. 1886-1903. W. H. DALL. (Extracted from the Transactions of the Wagner Free Institute of Science. Philadelphia, Vol. 3, part 6, pp. 1541-1620. 1903.)

Mr. Dall's long and attentive study of the Florida Tertiary has brought him to some important and very interesting conclusions, viz.:

1. The Florida peninsula has experienced a tilting by which the eastern margin has been elevated between twenty and thirty feet, and the western coast depressed the same amount.

2. The hypotheses propounded by Dr. J. W. Spencer involving the elevation of some of the Antilles and Florida many thousand feet and their submergence within a comparatively recent period, are not accepted. "Indeed to me the proposition is inconceivable as a fact and incompatible with every geologic and paleontologic fact of south Florida which has come to my knowledge."

3. The Oligocene, known in Europe, has its equivalent in Florida.

4. The Alaskan lignite beds (the Kenai formation) are probably Oligocene.

5. The marine Oligocene limestone that forms the substructure of the Floridan peninsula, has been drilled to the depth of more than 2000 feet without definitely reaching the subjacent Eocene.

6. The Oligocene was terminated by great physical changes, such as the uplifting of the middle American highlands, the larger Antillean islands and the peninsular island of Florida. The two Americans were united, and at the north the boreal coasts were depressed "and the waters of the Miocene sea were extended over the ruins of the Oligocene forests."

7. Along the gulf coast the transition to the Miocene was sudden, involving an absolute and complete change of fauna. The change was from subtropical to cool temperate.

8. Since Miocene time to the present, "no discontinuity of the link uniting North and South America is probable, and certainly none amounting to a free communication between the two oceans." As the Miocene elevation continued Florida became united to the continent by the closing of the Suwannee strait and cold water was permanently excluded from the gulf. The culmination of this movement ended the Miocene.

9. By a downward movement of the continental border the Pliocene was introduced, allowing the return of the fauna of southern latitudes. Some of these subtropical species are known to have reached as far north as Martha's Vineyard, although the approach of the Glacial period, which terminated the Pliocene, partly obliterated the records of the Pliocene, and such records are fragmentary even as far south as the Carolinas.

10. The obliteration of Pliocene life caused by the Glacial epoch was nothing like the "clean sweep" at the beginning of the Miocene. "The latter is the sharpest and most emphatic faunal change since the Cretaceous on our coasts." This summary of the changes between the Vicksburg and the Glacial epoch is regarded by Mr. Dall as the most important result of the study of the Tertiary fauna of Florida.

The author also summarily states what is known of the various Tertiary formations at the type localities in the southern and eastern states, beginning with the Vicksburg limestone and ending with the Pliocene of the Carolinas, including lists of fossils belonging to each. This general review is then followed by a summary in tabular form showing the relations of the faunas to one another and statistics of the work covered by the text. During the progress of Mr. Dall's work approximately eight thousand three hundred and fifty species have been discussed or compared, and eight hundred and sixty new forms described. More than fifty new group names, from sections to genera, have been proposed, and more than five times as many reduced to the rank of synonyms or belated. "The number of species known at present between the beginning of the Oligocene and the present time is between three and four thousand, probably less than half as many as will eventually be obtained and discriminated."

In conclusion the author mentions certain Pleistocene fossils, seventy-one species, on the west coast of Florida, and human remains, both found in a sandstone, of the former five being now extinct.

The work which has been accomplished by Mr. Dall, in this long and systematic study here so well summed up, is destined to hold its place as an American standard for many years, and constitutes a masterpiece of American geology and a monument to the author *aere perennius.*

N. H. W.

Text-Book of Geology. By SIR ARCHIBALD GEIKIE, F.R.S. Fourth edition, revised and enlarged. Pages 1472, in two volumes, paged continuously; with 508 figures in the text. London: Macmillan & Co., 1903.

In the ten years since the last previous edition of this thoroughly admirable text-book, abundant progress has been made in the collection of observed facts, and in their correlation and explanations, by many geological surveys and by a multitude of individual workers. The author has sought to include whatever is important in these latest discoveries and discussions, adding frequent references to the recent geological literature of all the world, and fairly stating the various views and arguments on both or all sides of every large question that yet remains unsettled.

He says of this edition in its preface: "Some portions have been recast or rewritten; others have been largely augmented by the incorporation of the results of the latest researches, while between thirty and forty illustrations have been added. As the new material thus supplied amounts to 300 pages, the work has now been divided, for more convenient use, into two volumes; but to facilitate reference their pagination has been made continuous. So uninterrupted, however, is the progress of investigation, that since the sheets of most of the book were successively printed off, various valuable memoirs have appeared of which it has not been possible to make use."

These volumes are not only the most comprehensive and luminous treatise ever published, in any country, on this science; but they are written in a very attractive style, being not less interesting to students for consecutive reading, than valuable to the advanced specialist for reference.

Two ample indexes increase the usefulness and convenience of the work, the first in 17 pages, of the authors quoted or referred to, and the second, in 66 pages, of subjects. W. U.

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CORRESPONDENCE.

THE LOESS AND ITS DISTRIBUTION. Permit me to add a few words concerning the loess distribution, and theories as to its mode of deposition, to the paper by Shimek which appeared in your December number.

While it is true that there are deposits of loess of limited extent and slight depth on parts of the Wisconsin drift, and also under the Illinoian drift, the only widespread deposit in the Mississippi valley region is one whose stratigraphic position is between the Illinoian and Wisconsin drift sheets, or the position occupied by the Iowan drift sheet. Like the Iowan drift it was not deposited upon the fresh surface of the Illinoian drift, but rests upon a soil, known as the Sangamon soil that had been formed on that sheet of drift. This is true not only in eastern Iowa and western Illinois, where the loess connects with the margin of the Iowan drift, but as well over the entire surface of the Illinoian drift wherever exposed outside the limits of the Iowan and Wisconsin drift sheets in Iowa, Illinois, Indiana, Ohio, and Kentucky. The part in eastern Iowa has been clearly shown by Calvin and his associates on the Iowa Survey to be a correlative of the Iowan drift, for it connects definitely with the border of that drift sheet. It is, therefore, known as the Iowan loess. Inasmuch as it occupies the same stratigraphic position from Iowa to Kentucky and Ohio, the writer and others familiar with the stratigraphic relation have felt no hesitancy in calling it the Iowan loess in this wide field. This, however, does not necessitate its being entirely a dependency of the Iowan drift sheet, as some have inferred. It simply means that the loess deposition, and the deposition of the Iowan drift sheet were essentially contemporaneous.

The mode or modes of deposition of the loess are still a problem, but one which may, ere long, be satisfactorily worked out. The careful study of fossils, which Shimek has been carrying on for several years can not but be fruitful of results, bearing as it does so strongly upon climatic conditions, and will probably be useful as a test of the validity of several of the hypotheses brought forward to account for the deposition. He has already used it vigorously in opposing the hypothesis of aqueous deposition, or a flooded condition of the country, which had been advocated by several geologists as a plausible explanation. There are two or more hypotheses of atmospheric deposition, on which the study of fossils will no doubt have a bearing. The hypothesis recently suggested by Udden (Jour. Geol. Vol. X, pp. 245-51, 1902), that a snow field may have existed outside the ice sheet and collected the dust blown in from dry and snowless neighboring districts, would suggest an arctic fauna which may not be born out by the fossils contained in the loess. The hypothesis of exceptional aridity in the Mississippi basin at the time of the culmination of the Iowan ice sheet, and a resulting excessive amount of atmospheric dust may also be tested to some extent by a study of the molluscan fauna, just as the opposite hypothesis of the flooding of the country has been. It is probable, however, that the study of fossils alone will be insufficient to fully clear up the question of the mode or modes of deposition of the loess.

Ann Arbor, Michigan, December 2, 1903.

FRANK LEVERETT.

NOTES ON FLUORESCENT GEMS. Following is the substance of a paper read at a meeting of the section of Geology and Mineralogy of the New York Academy of Sciences, Nov. 16, by Mr. W. G. Levison.

"Fluorescence or the property of reducing the wave-lengths of certain luminous rays enhances the beauty of a few colored gems under conditions which lessen he effectiveness of others that do not possess this property. Garnet, for instance, which is non-fluorescent, loses its rich crimson color and becomes dull gray in pure blue light On the contrary, most kinds of ruby and ruby spinel, and pink topaz respond to light-rays above the red on account of their fluorescence, and in blue-violet light still display their characteristic tints. The red color of the ruby is somewhat developed by the light of the air-gap spark and an uncovered Crookes tube. It is intensely excited by the cathode rays. Willemite displays a beautiful greenish yellow color not only in ordinary light rich in the yellow-green rays, but also in light consisting chiefly or wholly of the more refrangible colors in which its characteristic color would be effaced but for the possession of fluorescence in high degree. This mineral is excited furthermore by some of the ultraviolet rays and by the Roentgen and Becquerel rays.

"Other materials which owe desirable tints to fluorescence are, pearl, opal, hyalite, chalcedony and kunzite (the new lilac spodumene). Hiddenite, the green spodumene, seems to be non-fluorescent. Impaired by fluorescence are triphane, a yellowish-green spodumene, which exhibits pink fluorescence in blue light; emerald, which shows crimson fluorescence in the upper part of the spectrum, and diamond, with greenish-blue to blue fluorescence excited by several kinds of energy but more or less masked in ordinary light.

"In fluorescent substances excitation produces a certain opalescence or milkiness which is sometimes of sufficient strength to be of importance. It cannot be taken as an indication of impurities in the materials. In the white diamond such a phenomenon is a detrimental quality.

"Fluorescence affords a simple and positive method of distinguishing some of the fluorescent gems from imitations. Glass is not fluorescent and hence is easily detected. Other compositions when fluorescent show different colors from the genuine stones. In doublets the cement appears as an opaque film and the components differ in behavior. Artificial pearls of high grade have not been examined, but probably they will behave like the genuine. Artificial, or 'regenerated,' ruby has been examined in a single specimen. It acts like the natural stone in blue light, while with the air-gap spark between iron or aluminum electrodes it has a brighter color than any of the several natural rubies which were examined."

The following gems were stated to be non-fluorescent: garnet, amethyst, Spanish topaz, yellow Brazilian topaz, sapphire, ordinary beryl, possibly Siamese ruby. E. O. HOVEY, *Secretary.*

SUESS' REMARKS AT THE CLOSING BANQUET OF THE NINTH INTERNATIONAL GEOLOGICAL CONGRESS. The closing banquet of the Congress at Vienna was one of those pleasant affairs which will live long in the memory of the attending geologists because of the general good fellowship. Tietze, as president of the Congress, presided at this banquet and spoke the official farewell in French, followed by Geikie with reminiscences in English. The latter told us that more than forty years ago he made his first visit to Vienna for the purpose of consulting with one of the great geologists of that day. Of those he then met, nearly all are now gone excepting Suess, then a young man beginning to attract attention, but since become known to us all through his masterly work "Das Antlitz der Erde."

This reference to forty years ago when both Geikie and Suess were young, visibly affected the latter. Towards the end of the speaking, Suess rose and with bowed head and a low voice increasing to considerable volume as he proceeded, spoke eloquently in German the following:

"My distinguished master, Sir Archibald Geikie, was so kind as to say that more than forty years ago he became personally acquainted with me. With my highly honored friend Baron Richthofen, it is rather near fifty years. What a memorable half century we have lived through! During this time, under the influence of increasing knowledge of nature, all human conceptions of the earth have changed. It is remarkable, however, to see how often the single inquirer, bent upon the object of his quest, fails to comprehend the broader aspects of a problem by whose details he is fettered, just as the stone-cutter clinging to the façade, cannot see the splendor of the structure on which he himself is engaged. And yet there is a special charm in geological studies precisely on account of the extraordinary range of accommodation that is demanded of the eye, of the same eye which now examines the disintegration of quartz in a thin slide under the microscope, now sweeps over snowy mountain peaks, over dark precipitous cliffs and verdant vales, and with commanding glance reads their structure in the features of the landscape. But not less is the demand on the adjusting powers of the mind. From the most subtle conclusions derived from an ingenious experiment the geologist must be able to lift the mental eye over hill and valley into the most distant parts of the universe. There the glowing spectra of nebulæ teach him that even now the great processes of world making are not yet ended. With the aid of instruments he can daily witness the greatest eruptions of superheated gases emanating from the body of our sun. Photography spreads before him the pictures of the desolate crater-fields of the moon.

"Returning to his earth he now perceives that the sum total of life's phenomena not only forms a single phenomenon, but that it is also limited by space and time. It occurs to him now that the stone which his hammer strikes is but the nearest lying piece of the planet, that the history of this stone is a fragment of the history of the planet, and that the history of the planet itself is only a very small part of the history of the great, wonderful and ever changing Kosmos.

"His heart then thrills; he feels called as a co-laborer on the most sublime problems in which feeble, mortal beings can take part. Then, too, he sees that the fundamental lines of structure coursing over the earth's surface have nothing to do with the political lines separating the nations. The vastness of the problem itself makes the concord of civilized nations natural, and they remain separated only through their emulation, all filled with the idea that mankind in general will most highly esteem that nation which is in the position to offer the most and the best of noble example, of new truth and of ideal worth.

"These are the words which have crowded into articulation at this moment when you, now gathered from all parts of the world, are about to disperse.

"For the continuation of the feelings that fill us today, and for continued inspiration for our noble science, I raise my glass."

CHARLES SCHUCHERT.

Vienna, Hotel Continental, August 27, 1903.

PERSONAL AND SCIENTIFIC NEWS.

J. S. DILLER read a paper before the LeConte club of San Francisco, on the geology of the Redding quadrangle, the study of which is just completed.

MR. G. H. ELDRIDGE of the U. S. Geological Survey has nearly ready for the press his detailed monograph on the oil fields of southern California.

WM. S. TANGIER SMITH, of the U. S. Geological Survey, is engaged in writing his report on work in the Dakotas and Wyoming, at Los Gatos, California.

O. H. HERSHEY is operating a gold mine in Humboldt county, California, which promises well, and is incidentally studying the geology of the Klamath mountains.

G. K. GILBERT and A. C. LAWSON spent several weeks in the high Sierras, in California, last summer, primarily for recreation, but with results of much geological interest.

N. H. DARTON, of the hydrographic division of the U. S. Geological Survey, has recently gone to Phoenix, Arizona, to direct investigations in artesian water supply at that place.

GEO. D. LAUDERBACK, of the University of Nevada, has leave of absence for a year, and is studying the crystalline schists of California, as a scholar of the Carnegie Institute.

R. A. DALY, of the Canadian Geological Survey is engaged to give a course of lectures on physical geography at the Summer School of the University of California at Berkeley, next summer.

MR. GILBERT VAN INGEN, late of the New York geological survey, has been appointed assistant in geology and curator of invertebrate paleontology at Princeton University, successor to Dr. Ortmann.

MR. H. V. WINCHELL gave an interesting description, with illustrations, of his last summer trip to the Copper River district, Alaska, at the November meeting of the Montana Society of Engineers.

DR. J. C. BRANNER, Vice-President and Professor of Geology at Leland Stanford Junior University, will leave for Europe in the early part of January on his sabbatical leave of absence from his university duties. Later on in the year he may visit Brazil and other parts of South America.

DR. GEO. E. LADD, DIRECTOR OF THE SCHOOL OF MINES at Rolla, Mo., has recently been appointed as Superintendent of Mines and Metallurgy of the Missouri State Exhibit at the World's Fair in St. Louis. Dr. Ladd had charge of the Massachusett's display of structural and ornamental stone at Chicago Columbian Exposition.

REMAINS OF A LARGE MASTODON were discovered recently in the village of Belvidere, N. Y. They were unearthed by Dr. James Johnson of Bradford and Mr. Alban Stewart of the Smithsonian Institution. The remains consist of three ribs and four vertebrae, each of the latter being six inches in width, indicating a very large individual.

THE PALEONTOLOGICAL DEPARTMENT of the Massachusetts Institute of Technology was fortunate last year in having donated to it by the different students of the Institute much excellent working material. The largest gift, a collection of Silurian and Devonian fossils from Kentucky and Indiana, was that of Mr. Eugene Burton of Louisville, Ky.

Marcus Baker, well known as a member of the corps of the United States Geological Survey, died of heart disease at Washington, Dec. 12. He was best known as a cartographer, was formerly connected with the Coast and Geodetic survey and spent several years in explorations in Alaska. He was cartographer for the Venezuelan Boundary Commission.

John Robert Proctor, president of the United States Civil Service Commission since December, 1893, died suddenly at the Cosmos Club, Washington, on December 12th. He was born in Mason county, Kentucky, on March 16th, 1844; was assistant on the Kentucky Geological Survey, under professor N. S. Shaler, from 1873 to 1880; and was state geologist of Kentucky from 1880 to 1893.

The Standard Dictionary. The new "twentieth century" edition of this well known work maintains the reputation which the first edition earned of being the most complete, the most concise; and the most accurate dictionary of the English language. Including the seventeen thousand words of the "Addenda," it defines about forty per cent more vocabulary words and phrases than the Century, and more than twice as many as any other dictionary. It must be used in order to appreciate its fullness and accuracy in defining scientific terms. Special features of the new edition include a plate illustrating the mechanism of wireless telegraphy, a plate in natural colors showing ninety-three American and European butterflies and moths, four pages illustrating the apparatus and results of Roentgen rays, and addenda which include under *a* alone some thirty-five additional mineral names, and twenty geologic and petrographic terms, only six of which fifty-five terms are defined in the leading rival of this work.

International Congress of Geologists—Ninth Session. At this congress, held at Vienna, last August, the various countries were represented as follows Algiers—Tunis, by 2; Germany, by 76; Austria-Hungary, 123; Belgium, 6; Bulgaria, 3; Canada, 2; Spain, 2; United States, 22; France, 31; Great Britain, 12; Greece, 1; East Indies, 1; Italy, 6; Japan, 2; Mexico, 1; Netherlands (Pays Bas), 1; Portugal, 1; Argentine Republic, 1; Roumania, 6; Russia, 33; Servia, 4; Sweden, 5; Switzerland, 14.

Americans present were the following: Drs. Robert Bell and T. L. Walker (of Canada); J. G. Aguilera (of Mexico); G. F. Becker (and wife); E. Blackwelder; A. S. Bickmore (and wife); S. F. Emmons (and wife); H. L. Fairchild; T. C. Hopkins; E. O. Hovey (and wife); H. F. Reid; C. Schuchert; J. W. Spencer (and wife); C. R. Van Hise (wife and daughter); T. W. Vaughan; H. A. Ward; L. F. Ward; and B. Willis.

The total number in attendance was 357.

The session seems not to have been a brilliant success in any respect. Papers were read mostly in German. There were few of more than passing interest. Four days were given to excursions, one of the most notable being the excursion led by Albrecht Penck and Eduard Richter in the glacial formations of the Austrian Alps, which, however, continued from August 28 to September 10, both inclusive.

To some of the foreigners there seemed to be a lack of attention and preparation for their convenience on the part of the local committee of arrangements. "There was no room provided at the headquarters for sitting, nor for writing, nor conversation, nor smoking; the only gathering-place was a large corridor, with no seats except four benches without backs, at tables intended for beer. A stand for beer and liquors had a prominent place. No daily program was printed, no list of registration was available until the last of the meeting, so there was no ready way of learning who was present, and no way of meeting persons whose acquaintance was desired. It was noteworthy that on the programs the foreigners were placed at the tail each day. It appeared to visitors as if the congress was a local affair, intended primarily for the pleasure of the Austrians. Foreigners, who may have traveled half around the world in order to attend the meeting, were set aside and neglected as if of no consequence." In these respects the ninth congress was a remarkable contrast with the other European sessions.

Canada and Mexico were contestants for the tenth session; and Mexico won. It will occur at Mexico city in 1906.

The total number of *adherants* of the ninth session of the congress is 641. Therefore a little more than half of the membership were in attendance.

UNITED STATES GEOLOGICAL SURVEY.

The attention of librarians is called to a congressional act approved March 3, 1903, which provides that "the Director of the Geological Survey shall hereafter distribute to public libraries that have not already received them, such copies of sale publications as may remain on hand at the expiration of five years after date of delivery to the Survey document room, except a reserve which shall not exceed two hundred copies." The sale publications are of three classes only,—topographic maps, geologic folios and monographs.

The original issue of Bulletin No. 182 entitled "A report on the economic geology of the Silverton quadrangle, Colorado," by F. L. Ransome, has been exhausted and a reprint has now been published.

The monograph (vol. XLV.) on the Vermilion iron-bearing district of Minnesota, by J. Morgan Clements, has recently been issued. The price, including the atlas, is $3.50.

Bulletin No. 217 on the general geology of southwestern Idaho and southeastern Oregon is ready for distribution. It was prepared by I. C. Russell.

An investigation of the lead and zinc deposits of the Mississippi valley is being carried on by H. Foster Bain. During the past field season he has studied especially two of the districts of this region. These two districts are, first, that of southeastern Illinois and adjacent portions of Kentucky, and, second, that of the Upper Mississippi valley.

The sulphur deposits of the Rabbit Hole Mining district of Nevada have been studied by George I. Adams. The deposits have been known for some years, and active mining in them has recently been undertaken by the Nevada Sulphur Mining Co.

On the 21st of next March will occur the twenty-fifth anniversary of the organization of the United States Geological Survey. It is proposed to celebrate the occasion by the publication of a special bulletin describing the organization and work of the Survey and giving something of its history. The parts relating to the work of the different divisions are now being prepared and the whole will form a welcome addition to the literature of science.

Bulletin No. 218, on "The coal resources of the Yukon," by Arthur J. Collier, has just been published.

The Columbia (Tennessee) geologic folio has recently been issued. It was written by Messrs. C. W. Hayes and E. O. Ulrich and is of special interest in the fact that it contains descriptions of some of the important Tennessee phosphate deposits.

A number of small oil and gas wells are known in the vicinity of Mount Carmel in southeastern Illinois and adjacent portions of southwestern Indiana. This district has been studied by Mr. M. L. Fuller and the results of his work will be included in the Patoka geologic folio which is expected to be ready for distribution about January 1st. No large pools have as yet been discovered. It is very probable that numerous pockets, some of them perhaps yielding profits on the investments, would be found if the region were thoroughly tested, although there is no reason to think that a very extensive oil field will ever be developed in this region.

The geology and the ore deposits in the Tonopah mining camp, Nevada, have been studied by Mr. J. E. Spurr who has arrived at conclusions of importance from an economic standpoint. In order to get the results of this work quickly before the people interested in this district a preliminary report, with a geological map, will be issued.

Topographic maps of the Newbern and Tarboro quadrangles, North Carolina, have been prepared by the Survey in co-operation with the Agricultural Department of that state. These maps are now ready for distribution.

In northern and central Ohio topographic maps of the following quadrangles have recently been issued: Bowling Green, Elmore, Fremont, Vermilion, Euclid, Cleveland, Wooster, Dublin, Deleware.

A conference of eastern hydrographers, called by Mr. F. H. Newell, chief engineer of the hydrographic division of the Survey, was held in Washington, October 28th to 31st.

The Snoqualmie (Washington) quadrangle is one of the topographic maps recently issued.

The Olivet (South Dakota) geologic folio (No. 96) is ready for distribution. It was prepared by professor J. E. Todd and is one of the four folios containing data concerning the water resources of South Dakota.

A party of the Survey, under the direction of Mr. N. H. Darton, is investigating the mineral resources of the Bighorn basin, Wyoming.

Mr. C. E. Siebenthal is investigating the underground water resources of the San Luis valley, Colorado.

Professor I. C. Russell has discovered a new artesian basin in the southeastern corner of Crook county, Oregon.

Cripple Creek:—The original survey of this district was made in 1893 and 1894 by Messrs. Whitman Cross and R. A. F. Penrose, assisted by Dr. E. B. Matthews. At that time comparatively few mines were in operation and none of them had gone deeper than 400 or 500 feet. Since then the number of mines has greatly increased and there has been remarkably extensive underground development throughout this district. These new conditions have made a resurvey of the district eminently desirable, if not absolutely essential to the economic development of the properties. So desirous were the chief mine owners of the district that the work should be done, and promptly, that the sum of $3500, equal to half the allotment necessary for the work, was raised amongst them by private subscription. This was turned over to the state geologist, Mr. J. W. Finch, and work was begun by Messrs, Waldemar Lindgren and F. L. Ransome, assisted by Messrs. L. C. Graton and A. W. Rock. The field work is now about three-quarters done.

Tin in Alaska:—In the summer of 1900 stream tin (cassiterite) was reported by Mr. A. H. Brooks in the York region, and later more information concerning this mineral was given by Mr. Arthur J. Collier. Now Mr. Collier reports that this mineral has been traced to its parent ledge,—a granite dike cutting limestone. This locality is about fifteen miles east of York on a tributary of Lost river, now named Cassiterite creek. York is a small settlement on the western extremity of the Seward peninsula and about ninety miles northwest of Nome.

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THE GEOLOGY OF LINCOLN COUNTY, SOUTH DAKOTA AND ADJACENT PORTIONS.

By T. A. BENDRAT, M. S., Spencer, South Dakota.

PLATES II-III.

As a portion of southeastern South Dakota, limited by the Big Sioux river and the 97° of west longitude and extending from 43° to 43° 30′ north latitude, Lincoln county bears the stamp of the Quaternary period and more especially of the Glacial epoch. While there are no Archean or Palaeozoic rocks to be found outcropping and only here and there some exposures of the Mesozoic, the drift formation, has contributed the greatest share to the present topography.

Topography and Drainage.

This area may be described as a very shallow trough, the axis of which runs in a S. W.-N. E. direction, from about north of Centerville to south of Canton. Its deepest depressions below the outermost edges of the trough, toward the N. W. and S. E. vary from 160 to 200 feet. It is, however, far from being equilateral, as its S. E. side rises abruptly toward the rim at about 27 feet per mile, while the region N.W. of the axis shows a gentler rise at an average rate of 6 feet per mile for the first 10 miles and 20 feet per mile for the last 5.5 miles. The real bottom of the trough is triangular, one side of which is formed by the axis of the trough, another by an imaginary line passing about 3 miles N. of Canton and 2 miles N. of Lennox, while the third side has to be sought for beyond the Vermillion river perhaps not far from the eastern flank of Turkey ridge. This triangle covers approximately 200 square miles, while that portion of the bottom of the trough which lies

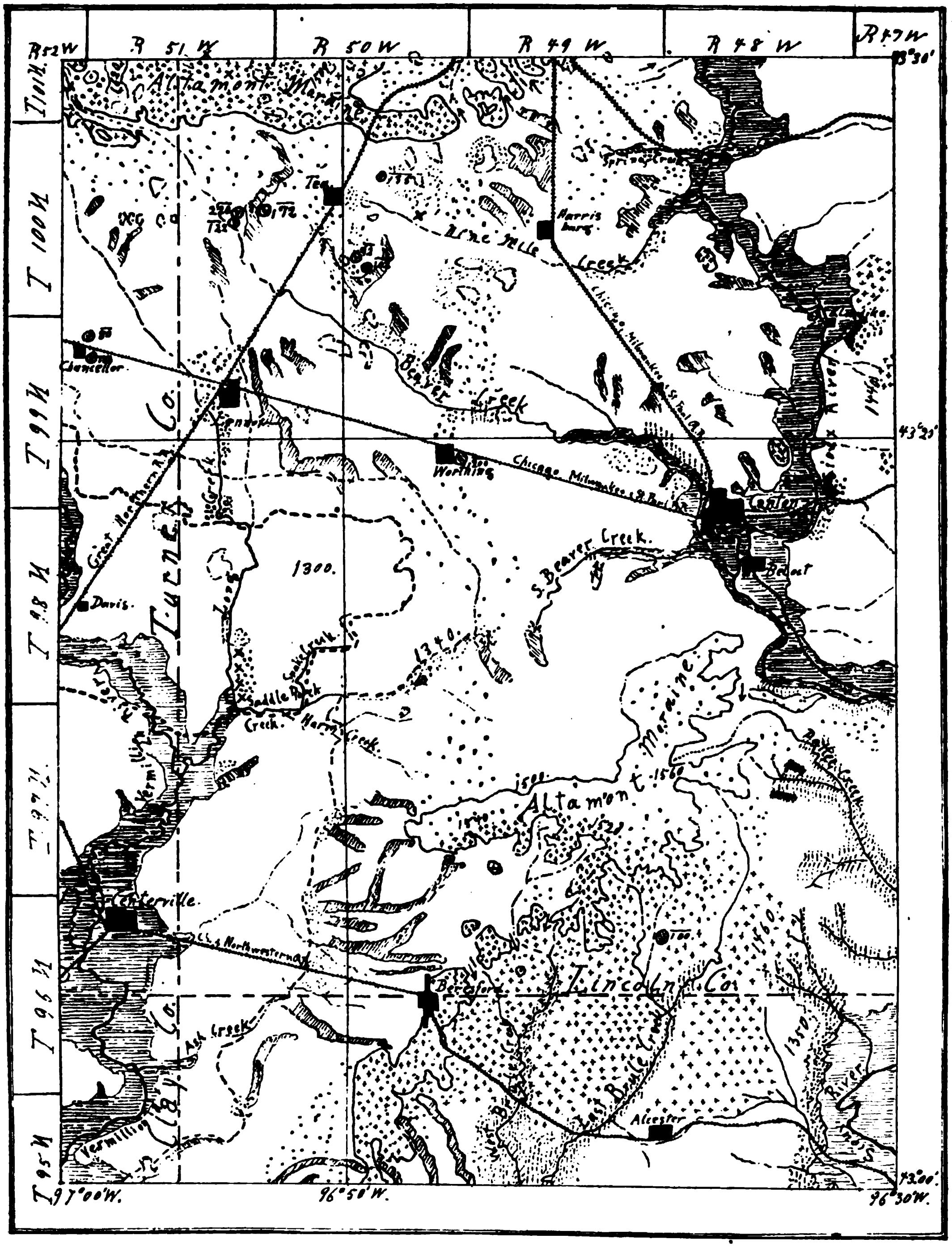
S. E. of the axis occupies only about 95 to 100 square miles, rising within three miles to a hight of about 65 feet above the bottom of the trough. The latter as a whole is bounded on the N. W. by a massive ridge which begins somewhat abruptly near the northern line of Iowa, then follows the "great bend" of the Big Sioux near Sioux Falls and maintains a more or less westerly course along the northern line of Lincoln county, until S. W. of Lake City, beyond the limits of the area, it sweeps around the west and N. W. continuing in that direction past Montrose in McCook county and Winfred, Lake county, for about 60 miles, up to Vermillion Point.

It has undergone not half as much erosion as its complement bordering the trough in the S. E. which vividly reminds one of a mighty plasmodium stretching out its tentacular pseudopodia in all directions, but mainly toward the south and east. This ridge begins its course about 2 miles south of Canton and trends for the first 6 miles in a S. W. direction, when it runs almost due west for about 7 miles. At that point it seems to end, rapidly subsiding to the bottom of the trough at an approximate rate of 80 feet per mile. A narrow spur, however, which projects about 5 miles east of that point from the southern side of the ridge for a distance of 4 miles, as well as some detached portions farther S. W. continue the ridge in an average southern direction through Beresford, beyond the southern limit of the region.

Both ridges rise to about the same relative hight above the axis of the trough, i.e. 180 feet, while in their highest elevations they are from 1560-1620 feet above sea level. Both serve as watersheds for the streams within as well as for those without the trough.

The largest streams of the area run almost parallel to each other at a distance of about 20 to 25 miles and may be taken as natural boundaries; these are the Big Sioux to the east and the Vermillion river to the west.

From the western watershed descend into the trough Nine Mile creek and Beaver creek which empty into the Big Sioux and Long creek which is an eastern tributary of the Vermillion river. But while Nine Mile creek takes its rise far below the foot of the ridge a little E. S. E. of Tea, deriving its waters apparently from a sand stratum which extends farther north

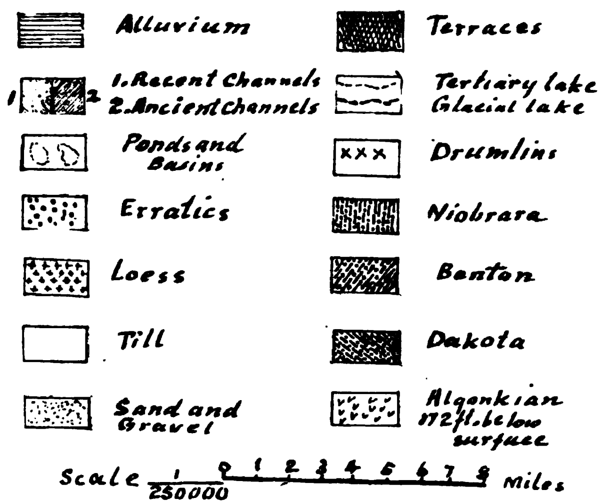


GEOLOGICAL MAP OF LINCOLN COUNTY, SOUTH DAKOTA, AND ADJACENT PORTIONS.
—T. A. BENDRAT.

into the body of the divide, the two other head beyond the limits of the area in the slope of the ridge. All three run for the upper and middle parts of their courses in more or less wide and comparatively shallow valleys.

As the general characteristic of all the waters traversing the area under discussion, the Big Sioux and the Vermillion rivers not being excepted, is to be mentioned their meandering course which is so commonly met with in regions of Quaternary physiography.

EXPLANATION.



The drainage system of the southern watershed which we may name for convenience sake "Canton ridge" comprises two classes of streams, those which issue from its northwestern side and those which head in its more hilly southeastern slope. But while those of the former class are only feebly developed, the second class of streams cut deeply into the deposits, thus forming a system of ravines and gullies and of spurs and elongated hills which is remarkable for its complex nature.

All of them head at about the same hight, i.e. about 1500 feet above sea level. All of them flow in deep channels widening rapidly as they proceed down the slope of the divide and enter upon the plain south of it. All of them receive a number of creeklets and brooks along their courses and thus cut up the country to the S. E. into two prominent terraces, so to speak, one at a general level of 1400 feet above the sea bounded by the southern slope of the Canton ridge and by minor western tributaries of the Big Sioux on the other side and traversed by the broad valleys of the two Brule creeks—the other terrace less significant about 100 feet below the level of the former and trending N.-S. along its eastern slope and bounded on the east by Pattee creek and the bottom land of the Big Sioux, above the level of which it abruptly rises to a relative hight of about 140 feet.

Only the upper course of Pattee creek which is the western tributary of the Big Sioux is here concerned. It falls at first to the E.N.E. at a rate of 26 feet per mile, which course it changes after a mile and a half into a northeastern one, turning after one mile's run to the S.E., thus forming a semicircle the diameter of which runs due W. and E. It then follows a southeastern direction, while bends and loops appear more frequently in its course and its grade is less rapid, i.e. a little less than 14 feet per mile.

East Brule creek maintains in its upper course a direction E.S.E. slowly sweeping around to the S.S.E. and forming in section 12 of Norway township a sudden bend to the S.S.W., which course it follows, until it receives its western fork. From this point on it turns more and more to the S.E., only occasionally showing bends, which are in the upper course more frequent. It descends at a rate of 22.4 feet per mile upon the upper terrace before alluded to, while its fall farther down is not by far as rapid, amounting to about 7 feet per mile and 4.4 feet per mile near the southern boundary of the area under consideration.

With West Brule creek about the same conditions hold good as with its neighbor. Both of them flow in valleys which are at first deep and narrow, but then rapidly widen out and unite with each other some distance beyond the southern limits of the area in order to form a broad flat-bottomed valley with gentle slopes.

From its head waters down to the southern boundary of Lincoln county West Brule creek entertains a course almost parallel to the west fork of East Brule creek, showing also about the same grade. In its middle course, however, the meandering character is more pronounced. It receives its waters from several heads in the upper slope of the divide and also from a number of brooklets, which rise in the west in shallow sags in the watershed. The narrowness of the spur thrown out by the divide in its southern side and mentioned above is nearly entirely due to the simultaneous cutting down agency of the headwaters of East and West Brule creeks which attack the readily yielding deposits of the spur from both sides.

Geological Features of the Region.
Algonkian.

From the circumstance, that the red Sioux quartzyte is found exposed immediately north of the northern line of Lincoln county in and by Sioux Falls and also about 10 miles farther west in the neighborhood of Parker and up to the northern boundary of Turner county, it may be assumed, that it is Algonkian rock which forms at least for the northern part of Lincoln county the "bed rock," a suggestion which has been verified by a number of borings in that part of the country.

Within section 11 of Perry township, about 3 miles south and 1 mile east of Tea, the Sioux quartzyte was struck at a depth of 102 feet, while a little farther N.W. it was found rising to 92 feet below the surface and still farther N.N.W., in the southwest corner of section 25 of Delapre township falling again to a depth of 135 feet, that is to say 43 feet within 4 miles. About 11 miles S.W. of the latter locality, at Chancellor in Turner county the Sioux quartzyte was revealed at a depth of 80 and 100 feet.

All these data fairly harmonize with the existence of a subterranean quartzyte peninsula traced by N. H. Darton through the eastern part of North and South Dakota, in the latter especially through Minnehaha, McCook and Hudson counties, and through Nebraska. The contours of this ridge are nicely brought out by Darton in his "Contour map of bed rock surface in a portion of the Dakota Artesian Basin" in his paper on the "Artesian Waters of a portion of the Dakotas" (part II of 17th Annual Report of the U. S. Geological Survey), which map has been amended by J. E. Todd in plate XI of Bulletin No. 2 of the "South Dakota Geological Survey." It is the southern slope of the ridge, which underlies at least to some extent the other deposits of the area under discussion; and that the surface of this slope is very irregular, probably throwing out spurs which flank deep valleys, may be inferred from the data of depth given above. Only a long period of subaerial exposure and the tear and wear of erosion and corrasion during Palaeozoic times can account for these unequalities of the hard "bed rock." The decision of the question put by Darton in his paper already referred to, p. 673 or 17th Annual, Part II, whether the quartzyte of this region is simply a metamorphosed portion of the water bearing Dakota sandstone underlying the western part of South Dakota and cropping out at the foot of the Black Hills, or not, should be the subject of a special petrographic study aided by favorable exposures.

Considering the fact that no member of the sedimentary Algonkian has as yet been reported from this region except the red Sioux Quartzyte, especial attention must be paid to a peculiar and exceptional condition revealed by a boring in section 25 of Delapre township. At that locality a bluish black slate was struck at a depth of 45 feet which was found to be so hard that the well-borer was about to quit boring, when he, after having gone for 90 feet through the slate, struck the red Sioux quartzyte and a little before water. Is this slate, overlying the red quartzyte and on the other hand directly overlain by the blue till, to be referred to the Algonkian or to a more recent age?—possibly the Cretaceous and more especially to the Benton shales of the Upper Cretaceous, as might be inferred from the usual occurrence of the Cretaceous formation above the "bed rock?" The probability of the latter suggestion is however much weakened by the consideration that the Benton shales are only feebly developed in the northern part of the region under discussion and also in the adjacent area to the west, as brought out by James E. Todd in U. S. Geological Survey, Irrigation paper No. 34, p. 16, where he estimates the probable thickness of the deposit in that region to only about 50 feet. Another circumstance, which may question the possibility of a correlation of this slate to a possibly hardened portion of the Benton shales, is that the occurrence of the latter at so high a level would be inconsistent with the usual level of the Niobrara, which is far lower, even in the northern slope of the trough. On the other hand the suggestion, that we have here to deal with another member of the Algonkian associated with the Sioux quartzyte, seems to be much favored by the association of slates with the quartzytes in the region of the Black Hills, where they have been observed by the writer and others to form the core of the mountains. The circumstance, that the red Sioux quartzyte, wherever it crops to the surface in and by Sioux Falls, is not associated with slates of any sort, is not deemed sufficient to invalidate the suggestion. Future borings in the neighborhood may throw, it is hoped, more light upon the question and furnish further data of interest.

Cretaceous.

As there have as yet been found in the county not the slightest traces of the Palaeozoic or of any Triassic or Jurassic rocks nor in the region farther west (compare U. S. G. S., Irrigation Paper No. 34, p. 12), the nearest localities, where the Carboniferous limestone was revealed by extensive borings being Sioux City, Iowa, and Ponca, Nebraska, we turn immediately to the discussion of the Cretaceous and more precisely to the Upper Cretaceous. The Lower Cretaceous has either been removed altogether or has never been deposited in this part of the Dakotas.

a: *The Dakota Sandstone*:

has obtained great importance in the water supply of the Dakotas, although the eastern limit of the Artesian waters falls without the area, being drawn by Darton about 25 to 38 miles west of it. No outcrops of the Dakota sandstone have been observed by the writer within the limits of the county in spite of its being recorded by Darton along the Big Sioux from Sioux Falls southward to Sioux City and even farther south, on his "Contour Map of the Upper Missouri River Region" (U. S. G. S., XVII Annual Report, p. 676), while J. E. Todd in his able paper on "The Moraines of Southeastern South Dakota" (U. S. G. S., Bull. No. 158), reports the Dakota sandstone only on the James river and its tributaries as well as on the Missouri. The Dakota sandstone is, however, revealed by borings, abutting, it is supposed against the red Sioux quartzyte farther north. In T.99N., R.51W., sec. 4 of Perry township the Dakota sandstone was struck at a depth of 150 feet, the head of the flow being 50 feet from the surface, while in sec. 9 of same township, about one mile farther south, the sandstone, struck at nearly the same level, gave rise to a flow heading 30 feet from the surface. Four miles N.W. of Lennox in T.99N., R.51W., the sandstone was found to be 210 feet below the surface, yielding water from that level down to 100 feet, while at Worthing, within sec. 9 of Lynn township the Dakota sandstone was revealed at a depth of 300 feet below the surface, yielding a fine flow of excellent drinking water.

In the southern part of the area, in sec. 23 of Norway township, near Linden, a very hard ("flint-like") sandstone has been reported to the writer, yielding a good flow.

It will be observed, that the Dakota formation in its position very closely follows the contour-line of the trough, being nearest the surface in the northern and the southern slopes and lowest near its axis.

b: *The Benton shales.*

The Benton group, which is usually found to be composed of dark clays along the Missouri river, is at places not readily distinguishable, although it is of a similar nature. It is not frequently exposed, and where this is the case, it sometimes grades imperceptably into the chalk of the Niobrara.

Along the northern bank of Beaver creek, N.W. and S.E. of the 43° 20′ N., a dark marly clay has been observed by the writer, the thickness of which could, however, not be ascertained.

Pattee creek and its western tributaries as well as the middle and lower courses of East and West Brule creeks seem to have their beds in the dark shales of the Benton, the latter being exposed in the banks of West Brule creek for about 10 feet above the level of the creek, where they are overlain by the Niobrara chalk and more recent deposits. As reported by Todd (comp. U. S. G. S., Bull. 158, opp. p. 144, sec. E-F), Brule creek continues to flow in the Colorado formation.

The Big Sioux has done his share in revealing to some extent the Benton group. In one case at least the writer noted the presence of a deposit of clays of a dark color below the general level of the Niobrara chalky series.

Although hidden to a large extent by talus sloping down to the bottom land of the Bix Sioux, the Benton seems to lie at a uniform level below the chalkst[illegible] S.E. corner of the county within T.96N. and T.[illegible]

While the Benton is found exposed only about 20-30 feet, well-boring has revealed its real thickness for instance at Worthing, near the axis of the trough 203 feet, and in T.99N., R.51W., N.W. of Lennox, 94 feet.

c: *The Niobrara Chalkstone.*

The chalky series of the Niobrara has been identified beyond doubt along Beaver creek, Long creek, the bluffs of the Big Sioux, Pattee and E. and W. Brule creeks.

One mile north of Worthing and two miles east of that town, within sec. 34 of La Valley township, it has been found exposed in the northern bank of Beaver creek for about 2-4 feet, while the rest of it was hidden by talus. It showed traces of fossils, which, however, were too fragmentary to allow of identification. Within the seventh mile east of Worthing, in the eastern bank of Beaver creek, a very fine exposure of about 10-15 feet of the chalky series was met with, comparatively rich in fossils. The most of them were "Ostrea congesta" *Conrad,* identified through the kindness of Dr. T. W. Stanton, paleontologist of the U. S. Geological Survey, and a large "Inoceramus" species, of which, however, only fragments could be found. The top of the exposure was found to be about 1320 feet above sea level.

Farther southeast, where the southern bank of the Big Sioux rises in high bluffs above the stream, west of Fairview, the chalky series has been found at practically the same level, i.e. about 105 feet above the stream. Within T.98N., R.48W., 2½ miles west of Fairview, it is exposed for about five feet in cuts at both sides of the road leading down the slope of the terrace to the bottom-land of the Sioux, the top of the formation being nearly 100 feet above the level of the stream.

In the southern part of the region the Niobrara is again met within the valleys of Pattee creek and East and West Brule creeks, in the latter exposed in places for about 30 feet. The bottom of the valley of the western fork of West Brule creek was found to consist of calcareous clays, while about 10 feet above the level of West Brule creek the chalky series was met with again, directly underlain by the Benton.

As to the thickness of the formation no absolute data were available from well-borers, who apparently take the chalkstone for a similarly looking deposit above or beneath the level of the Niobrara. The Niobrara in this part of the Dakotas certainly does not exceed a thickness of 60 to 100 feet, while in the area west of the 97° it has been reported to gradually and constantly gain in thickness (comp. U. S. G. S. Irrigation Paper No. 34, p. 16). In the southern part of the county its base has been observed at a general level of 1375 to 1380 feet above sea.

The Tertiary Sands.

The Tertiary deposits are to a great extent concealed by the overlapping drift. They seem to be represented only by a stratum of very fine sand, which is, however, not continuous, but is rather distributed in the form of lenses, which seem to thin out toward the periphery, thus indicating the drainage system during Tertiary times and more especially during the Miocene and Pliocene. Wherever they may be revealed by deep borings or in natural or artificial exposures, it will be found somewhat difficult to distinguish them from the overlying sands and gravels of the drift. Where they are partly hidden from view by the sliding of deposits higher up, their presence is betrayed by the way in which they aid a stream to widen out its channel, transforming it into a broad valley by yielding readily to the scouring action of the currents, while the overlying clays, deprived of their base, tumble, sometimes in bulky masses, into the rushing stream. This phenomenon, which has been observed by the writer along the Missouri at Dakota City, where in 25 years from a farm of 160 acres all has been devoured by the raging stream with the exception of 7½ acres, seems to have also prevailed during the formation of the broad valleys of East and West Brule creeks, as well as the main stream and the wider portions of the valley of the Big Sioux. The data obtained by the writer are not sufficient to trace the outline of the drainage system mentioned above, which may become the subject of a more detailed study, when farmers will become more enterprising and undertake more extensive borings.

There is, however, some evidence of the former existence of a Miocene lake, which possibly extended during Pliocene times, six miles and a half south of Lennox, i.e. in the very bottom of the trough, in the eastern bank of Long creek, fine sands and gravels were found to form the base of the drift at a level of 1256 feet above sea. They made the impression upon the writer, that they had been deposited in still waters. They may with some right be referred to the later Tertiary and may indicate the bottom of the lake, while its shore has to be possibly sought for in a locality about four miles N.W. of Lennox, where borings revealed a stratum, four feet thick, of fine dry sand, as we usually find it on the beach. This was found at a level of about 1268 feet above sea. Although a distinct shore line has not been found, having become obliterated by the Pleistocene ice sheet, an approximate outline can, however, be traced, aided by the topographic map (Canton sheet of the U. S. Geological Survey). There might be distinguished two stages of this Tertiary lake, during the latter of which the lake seems to have extended along the axis of the trough towards the N.E., thus following a probable sinking of the region in that direction during Pliocene times. Ultimately it became obliterated, taking part in the general elevation of the country, which is supposed to have inaugurated the Quaternary. It was most probably drained through channels to the east, one of them, possibly the most important one, following the course of the present South Beaver creek within T.98N., R.49W., shown on the occompanying map, on which also the approximate outlines of the lake during Miocene times are given. The probability of a refilling of the empty lake basin by glacial waters and the formation of a glacial lake, although of less extent, will be discussed later on.

The Pleistocene.

a: *Drift Sands and Gravels.*

Representing the main source of the water supply, the sands and gravels of the drift are found to form a stratum, which is not in all portions of uniform thickness, but which might be said to be continuous, unlike the Tertiary sands. At places these sands and gravels are usually deeply buried beneath the till, thus, for instance, in T.100N., R.50W. in sec. 35 of Delapre township at a depth of 94 feet, and about half a mile west 107 feet below surface and still farther west for another half mile at a depth of 100 feet, while at little farther in the same direction in the S.W. corner of sec. 34 of same township, they are found to rise to 14 feet below the surface, yielding a fine drinking water. On the same land is an old well dug about twenty-three years ago to about the same level, developing a strong flow, but which was abandoned for some reason for a long time, until lately it has been cleaned again, when it began to show the same strong flow, the head of which is at constant level of four feet below the surface.

Also in sec. 2 of Perry township within T.100, R.50W. and in sec. 7 of La Valley township the sands of the drift are near the surface, the sands being struck in the former locality at a depth of only 16 feet, the water at 20 feet, while in the latter locality the sand was met with four feet from surface, the water 22 feet below.

In the southern part of the region, for instance at Beresford, gravels and fine sands are revealed by borings at a depth of 44 feet, at Centerville sands at a depth of about 100 feet, while at the former locality the water was struck 84 feet and at the latter 108 feet below surface. At and in the vicinity of Worthing sands were revealed, intermixed with "hard shells," at a depth of 87 feet, while the water was found near the base of the layer about 97 feet below the surface.

Not all of the sand and gravel stratum seems to carry water, but that there must be a constant flow in certain directions within the stratum, seems to be evident from the data given above, but especially from the peculiar condition found in section. 34, S.W. quarter, of Delapre township.

At many points the sands and gravels come to the surface, along the margin of ancient basins in the inner slope of the Altamont moraine and south of it, viz.: in the neighborhood of ancient channels of glacial or Champlain age; in sags and other outlets not only of the northern watershed, but also in the "Canton ridge" and to some extent along the watercourses of the region on Nine Mile creek, Beaver creek, Long creek and in the banks of the Big Sioux; also on the western tributaries of Pattee creek as well as on the main stream. Gravels are also reported from southwest of Beresford.

The study of the composition of this sand-and-gravel stratum is of great interest in so far, as the different layers of fine and coarser gravels and sands, indicate different phases in the development of the drift. Several sections obtained by the writer from different localities, may serve to illustrate the arrangement of the layers.

1. *Section of cut in southern bank of Nine Mile creek, within T.100N, R.49W, 2½ mile E. and 1 mile S. of Harrisburg.*

	Feet.	Inches.
Dark brown clay graduating above into the black soil...	2½	
Seam of flour-like gypsum, probably resulting from a layer of thin calcareous plates, coated with gypsum........		3
Layer of gravel and bowlders associated, the latter diminishing in size upward and yielding to a stratified arrangement of the gravels, the seams being tinged black and rust red alternately.......................... (the bowlders being derived from granite and other igneous rocks.)	3	
Bluish clay, weathering yellow, nearly free from pebbles and bowlders. (Base of this being frequented by bowlders, 3 to 4 feet in size............................	3	
Seam, consisting in its upper portion of coal (½ inch) and in the lower one of a compact light buff colored clay .... (a hardened soil.)		3
Gray sands, obliquely stratified, dipping at an angle of 20° to the S., streaks of rusty, iron-charged sand alternating with the gray..............................	1-2	

The base of the exposure is about two feet above the bridge.

2. *Section 1 mile N. and 1½mile E. of Worthing, in the northern bank of Beaver creek.*

	Feet.	Inches.
Cobblestones and granite bowlders, 2 to 2½ feet in size..	2-3	
Seam of black coal in the upper and compact buff colored clay in the lower part............................		2-3
Buff colored loam, the base of which could not readily be distinguished, in the upper and milk-white chalkstone, showing traces of fossils, down to talus..............	4-6	

3. *Section of gravel pit, one mile S.E. of Tea, East of R. R. tracks.*

	Feet.	Inches.
Dark brown pebble clay, graduating upward into black soil	2	7
Light buff colored clay carrying calcareous concretions and a greater percentage of pebbles......................	1	5
Cross-bedded seams, 1½ to 2 inches thick, of rusty and gray sands and fine gravels, occasionally showing laminated and even flexed structure and at one point the concentration of the rusty sand into a cylinder, or sphere, the cross section of which is fairly brought out by the gray background.......................	2	
Talus	4	

4. *Section of gravel pit W. and E. of Great Northern R. R., about one mile S.E. of Lennox.*

	Feet.	Inches.
Yellowish till	1½	

	Feet.	Inches.
Brown cobblestones lining a thin seam of flour-like gypsum mixed with calcareous matter, probably the same as observed in Sec. 1. Then medium sized gray gravel, underlain by an iron charged cobblestone and bowlder stratum	1	
Fine gravel and sand	¼	
Gravel growing coarser at a uniform rate and yielding to cobblestones at the base of the layer, where intermixed with bowlders (½ foot)	1	
Obliquely laminated fine gray sands and gravels, dipping to N.		9
Base: Coarse gravels, replaced lower down by big cobblestones and bowlders, ½ foot in size	½	

Western end of same section.

	Feet.	Inches.
Yellow till	2	
Coarse gravel and cobblestones, charged with iron		9
Seam of fine gray gravel and quicksand		2
Brown medium gravel		5
Gray coarser gravel		9
Reddish brown coarser gravel growing in coarseness toward the base of the layer, where it is replaced by cobblestones	1	
Fine gray gravel and sandstone obliquely laminated with rust-brown thin streaks, the dip being to the south	1	6
Talus.		

5. *Section of cut within second mile south of Lennox cemetery in eastern bank of Long Creek.*

	Feet.	Inches.
Dark clayey soil, carrying cobblestones	1	6
Coarse gray gravel		5
Coarse gray gravel over- and underlain by thin seams of fine and medium rust-brown		4
Fine gray sand, obliquely laminated	1	6
Seam of a mold-like matter (old soil)		1½-2
Brown layer of very coarse gravel and cobblestones	1	6
Gray medium gravel	½	
Talus.		

6. *Section of cut, 6½ miles south of Lennox, on eastern bank of Long creek.*

	Feet.	Inches.
Black soil	1	
Light gray gravel intermixed with calcareous matter	1	3
Brown coarse gravel	1	6
Finer gray gravels intermixed with bowlders of ½ foot in size of hard light yellow (Silurian) limestone, green schist and greenish gray chalkstone		4
Fine gravel and quicksand of loose texture		9

The history of this complex sand-and-gravel stratum of the drift is read in general outlines about as follows: There was a time of floods and torrents, steadily increasing in transporting power, followed by a cessation, of quiet accumulation of finer materials, of aeolian action upon dry sands and of soil formation and vegetation to some extent. This was succeeded by another time of floods and strong currents, which, however, lost their swiftness in the course of time, until there was inaugurated another interval of rather quiet accumulation, which was in turn succeeded by relatively longer and shorter periods of stronger and weaker activity, until the till became deposited.

The material of the stratum apparently displays a great variety of rocks of igneous as well as of metamorphic and sedimentary nature.

Of the ingredients of the drift in the bluffs on the Big Sioux the following may be noted:

Cobblestones of 3x2½, 3x2, 2½x1½ inches in size, of feldspatic granite, carrying titanite, the mica being of inferior quantity, while the orthoclase at places very beautifully exhibits the laminar cleavage structure. Pink granite of less stability, disintegrating, the mica plates, however, being recemented by calcium carbonate, which partly coats the stone. The quartz grains and feldspar crystals are of about the same size and the percentages of the three ingredients are nearly equal.

Gneiss of dark gray color with brownish, greenish and reddish shades, coated to some extent by lime; at some places the surface is rendered somewhat cavernous by the removal of the feldspar. The quartz as well as the feldspar is of medium size, while the mica at places has been altered into chlorite, only isolated traces of the original mica being preserved. The rock is of considerable hardness. Crystalline limestone (Silurian) of gray color passing into lighter and darker yellow shades and exhibiting in some instances striae, which run parallel to each other, and also spicules of sponges and fragments of graptolites.

Pebbles from 2x1½ to 1¼x½ inches in size, of dioryte of dark color with darker and lighter shades of green and brown, with large and showy plagioclase feldspar crystals and the hornblende very conspicuous; quartz-dioryte of somewhat brittle texture and dark color, carrying besides titanite some minute specks of gold, while the hornblende has become disintegrated to some extent into chlorite; quartz-schist of a dark grayish shade and medium sized grains; talcose schist, weathering almost black, but on fracture readily showing the characteristic lustre and the greasy feel of talc; hornblende-schist of dark green shades, showing veinlets of quartz running parallel to the schistosity of the rock; black flint, the break of which exhibits the characteristic concoidal surface; milk quartz and yellowish brown quartz, partly coated by lime; very brittle, soft shaly limestone of light color, showing impressions of shells, which could not, however, be identified; argillaceous sandstone, easily breaking into thin slabs, of gray color and occasionally tinged by iron oxide; light gray argillaceous shale, at places colored by iron oxide, possibly a phase of thel ast; light yellowish finely stratified clayey sand, exhibiting concretions of iron oxide and clayey casts of probably vegetable matter.

From the drift, exposed in the banks of Beaver creek, may be noted: cobblestones of the size of a hen's egg of gray granite with medium quartz grains and feldspar crystals of nearly equal size; nevadyte (granitoid rhyolyte) of a yellowish gray, carrying garnet (spessartite?); fine grained granitoid rock, speckled all over with minute dots of iron oxide; hornblende-granite with pink orthoclastic feldspar crystals, holding iron oxide: pinkish quartzyte of very firm texture; black flint, exhibiting conchoidal fracture; yellowish quartz; magnesian limestone, more or less crystalline, showing on yellowish-brown surface cross-sections of crinoid stems and fragments of heads; somewhat compact clay, highly charged with iron sesquioxide; black shaly coal, containing cylindrical hollows probably previously occupied by roots and rootlets.

Pebbles have been noted of medium grained granite with pink feldspar crystals and abundant mica, the granite showing lighter and darker phases; andesyte; syenyte, the hornblende of which has become changed into chlorite, while the orthoclase is in phenocrysts; fine grained gneiss of dark color; gray quartzyte; hornblende-schist; chlorite-schist; dark brown flint, with conchoidal fracture; dark augite-dioryte with dirty white and pink plagioclase crystals. quartz of various shades; whitish chalkstone, probably Niobrara.

The coarser material of the drift shows at many places a coating of finer detritus, cemented together by calcium carbonate, and is very often found to constitute a firm conglomerate, tinged a reddish brown by iron oxide, while the sand grains of the finest material are very well rounded and of great clearness and translucency. Minute grains of garnet and also mica plates are often associated with them.

A very fine sand, which covers the road leading up the divide south of Beloit, and which might be met with also in the southern part of the region, assuming in rearranging itself at both sides of the road a laminar structure, seems to belong to a phase of the drift, underlying the till, having been and still being washed down by rains from that horizon. This layer, which apparently replaces at points the coarser material of the drift and which may be considered a transitionary link between the sands and gravels and the sandy clays of the till, consists of a fine clayey sand, horizontally stratified and of light gray color, which nicely contrasts against the bright brick red of oval iron accumulations, 2 to 3 inches long, holding in a blackish nucleus delicate pappus-like threads of gypsum. These accumulations are, however, not confined to this layer, but also occur higher up in the till. The upper limit of this deposit is at places very distinctly marked, while its base has been observed only in one instance, viz.: 2½ miles west of Fairview in the bluffs of the Big Sioux, where it is found at a level of about 100-105 feet above the level of the river, underlain by the Niobrara chalky series. The thickness of this phase of the drift formation amounts at this point to nearly 52 feet, while about four miles west of Fairview it is only exposed for 30 to 35 feet. The layer reported by Todd from the Big Sioux, 3½ miles east of Fairview, consisting of "fine sand with large rusty concretions" and represented in Bull. No. 158 of U. S. G. S., p. 83, seems to belong to the same phase.

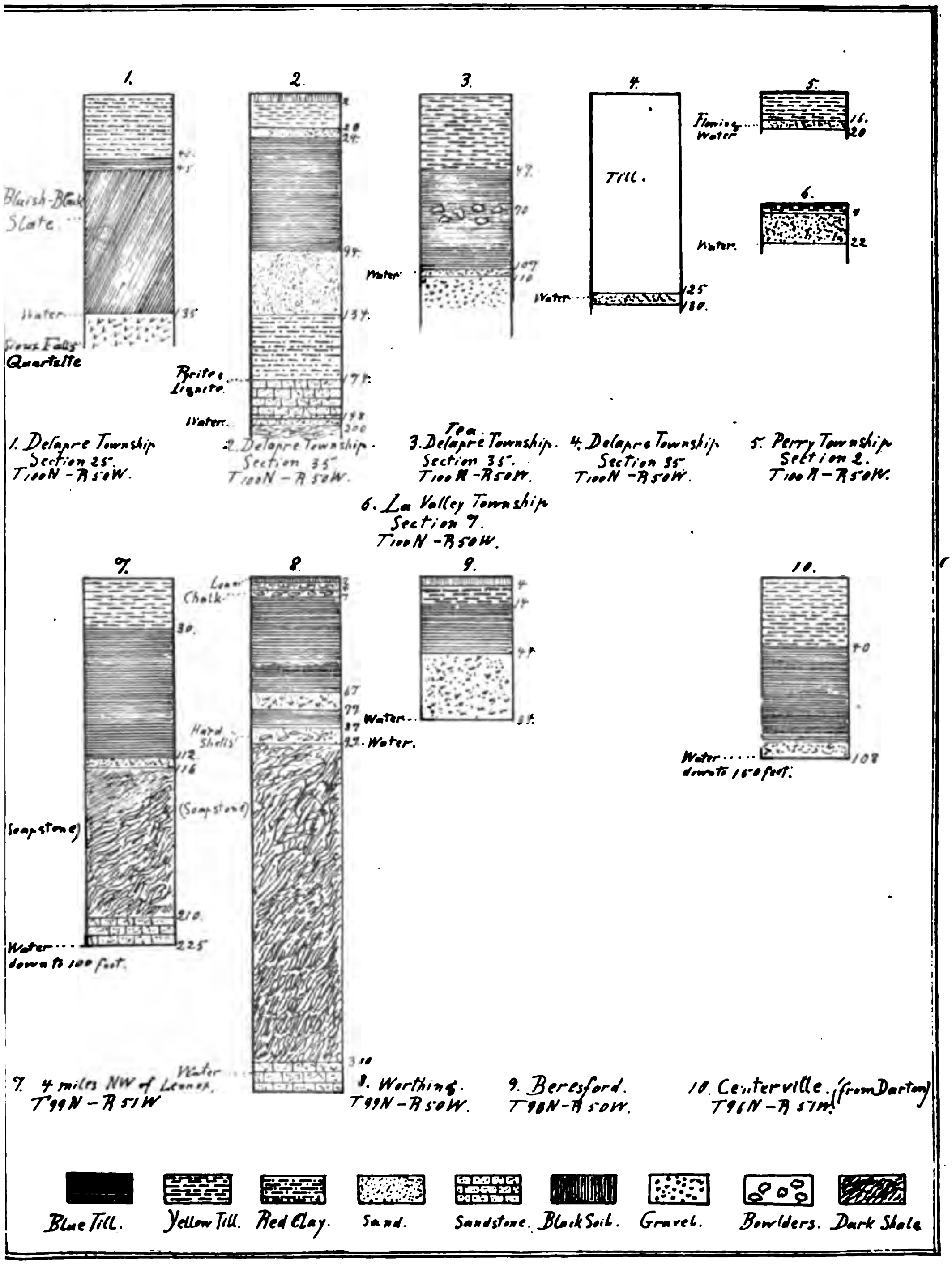
The thickness of the sand and gravel deposit as revealed by borings, although it varies greatly in different parts of the region, would average nearly the same as that reported for the clayey sands, viz.: 40 to 50 feet.

The role, which these sands and gravels play in the water supply of the region, has already been referred to. Shallow as well as deep wells are furnished by the drift, the water of which is in some cases charged with iron, in others with alkali, but in most cases fairly palatable for man and beast. In the household of nature they are of greatest importance in so far as most, if not all, of the water-courses of the region head in this deposit. The rain-water as well as the melting snow and ice, received either directly or indirectly, seeping through the till down to this level, supplies not only the creeks, brooks and brooklets by terminal and lateral leakage, but also a great number of ponds, the waters of which are found to be relatively pure, which would not be the case, if they did not receive their supply, to some extent at least, from below.

b: *The Blue and Yellow Till.*

Overlying the sands and gravels of the drift, the till constitutes far the greater amount of the surficial topography of the region, excepting only those portions which are occupied by the loess. We usually distinguish between the yellow till and the blue, of which the former, occupying the upper portions, has lost its original bluish color, and has asumed a rather yellow tint, which frequently shades into a light buff, and at places yields to a dark brown or a dull red. It is an unstratified material, consisting of clays and sands intermixed, and pebbles cobblestones and subangular bowlders of about the same rocks as enumerated above, while the percentages of the constitutents differ in different localities. With them are associated those brick red iron accumulations, described above, and elongated, white calcareous concretions, which have been sufficiently described by Call in "The American Naturalist," May, 1882, as chiefly occurring in the loess. The coarser material is as a rule irregularly disseminated through the matrix. In so called "pockets," however, in lenses and strips, interpolated in the till, they have assumed stratified structure.

It is these upper layers of sand and gravels which separate the till into at least two members, which, however, have nothing to do with the division of the till into blue and yellow till, sometimes both members being found to consist of blue till, as for instance at Worthing. Here the separating sand and gravel stratum is 10 feet thick, while the upper member of the till has a thickness of 60 feet, the lower of only 10 feet. In sec. 35 of Delapre township, N.W. quarter, the till is divided by a stratum of sand, only 4 feet thick, into an upper member of 20 feet yellow till and a lower one of 70 feet blue till, the sands in either case yielding no water. The total thickness of the till,



LOGS OF WELLS IN LINCOLN COUNTY, SOUTH DAKOTA.

including the upper sand and gravel stratum, varies within the limits of the region from 80-125 feet.

Even the till yields water, although it is of inferior quantity and quality, being sometimes impregnated with H_2S. It is probably due to the joint-structure of the till, that the rain sinks below the surface in fissures and cracks, so that, for instance at Tea, water is struck in digging cellars and cisterns at at depth of about 8 feet.

Whether the red clay, which is at points more or less free from sand, but at others hardly to be distinguished from, the till, so far as its constituents are concerned, and which overlies the yellow and the blue till or underlies the blue till, has to be considered an independent member of the drift or represents only another phase of the till, must be left undecided for the present. It has been found by the writer to crop out to the surface in sec. 25 of Delapre township, S.W. quarter, where it develops a thickness of 40 feet; and also within one foot from the top of the bluffs, facing Fairview, where it forms thin layers above and below a band of calcareous concretions, which stand with their axes vertical. It has been found by boring east of Tea to underlie the blue till and also the fine sands underneath at a depth of 134 feet, 40 feet thick, while at Worthing it is found to underlie the black loamy soil at a depth of only 2 feet, with a thickness of 5 feet, overlying the blue till.

Especial attention may be called to the exceptional occurrence of clay of "buff-cream" color, mottled by a greenish sand, which is intermixed with the clay. It has been met with by the writer only at one locality, i.e. eleven miles south and within a third of a mile east of Canton, in a cut on the northern side of the road, where it occupies the very base of the exposure of about 6 feet of the yellow bowlder-clay. It is also laid bare in the road itself. The writer suggests here a rearrangement of clays and greenish sands from above, washed down to the foot of the cut and spread over the road by rain.

c: *The Occurrence of the Loess.*

The Loess, which is still the subject of much dispute among geologists, so far as its origin is concerned, occupies, as already indicated, only limited portions of the area. It is met with less in continuous sheets, but rather in isolated patches, cladding preferably the highest parts of the region, although it descends occasionally by means of its creeping ability onto lower levels. As is indicated by the subjoined map, it is confined to the back of the Altamont moraine in the most northern part of the region, where it is very feebly developed, becoming more pronounced beyond the northern limit of Lincoln county at Sioux Falls, and even there attaining a thickness that does not exceed about 6 feet. As already reported by N. H. Winchell of the Geological Survey of Minnesota, the highlands extending along the eastern bank of the Big Sioux through Sioux and Lyon counties, Iowa, are capped by loess, which shows a thickness of 10 feet approximately.

In the southern part of the area the loess is far better developed than in the north. Although its thickness here has not been ascertained, it has been found to mantle all the higher points west of Hudson to Beresford and also between the latter town and Alcester, the surface being strewn with numerous calcareous concretions which are so characteristic of the loess, for which reason they have been called by German geologists "loess-kindchen," while the loess itself shows a light buff color, grading into deeper and lighter shades.

In the western part of the area under discussion the loess has not been met with, neither along the Vermilion river nor along its eastern tributaries, the region between the Vermilion and the 96° 50′ being chiefly occupied by the "bowlder-clay" or till.

The material of the loess consists, contrary to the till, of only two ingredients, viz., minute, more or less rounded grains of silica and fine grains of clay, being cemented together by the still finer detritus of the two. No pebbles or bowlders are present, and while the till shows no traces of stratification, except in its sand-and-gravel-"pockets," the loess exhibits more or less distinctly a stratified structure.

d: *The Altamont Moraine and its features within the limits of the area.*

The two ridges, which we have already discussed to some extent with reference to their importance as water-sheds of the region and which exhibit a decidedly moranic character, are portions of the so called "Altamont"-moraine, which marks the more stationary boundary of the *first* extensive ice sheet of the Wisconsin ice epoch invading the Dakotas during late

Glacial times—the "Dakota" glacier. But while during this epoch the moraine seems to have been continuous also along the western bank of the Big Sioux between Beloit and Sioux Falls, thus connecting the northern and the southern members with each other, there exists now, as will be noted from the map, a gap of about 20 miles, where only here and there isolated hills, composed of drift-material, speak of the former presence of the lateral moraine. They show more or less flattened tops and rise in the knobs, which are occasionally developed, a little N.N.E. of Canton, to a hight of 1360 feet, farther N.E., about 2 miles from Canton in the most prominent of these hills, to a hight of about 1440 feet, near Klondike in sec. 17 of Dayton township to 1380 feet, and in the S. W. corner of T.100N., R.48W. to nearly 1440 feet above sea-level, i.e. in the average to a hight of 53 feet above the axis of the trough. From these data it appears that this portion of the lateral moraine was less developed than the now detached northern and southern members, and the reason for this seems to be the existence of a swift current at that time, which flooded a channel, now occupied by recent deposits and the waters of the Big Sioux, and which, rushing along the eastern flank of the ice-sheet, removed at least a part of the detritus of the glacier as soon as it became deposited. There is also some reason for supposing that at the time of the invasion of the region by the glacier the base of the glacier was inclined towards the axis of the trough and had also subsided towards the east along the axis so that much of the sub-glacial drainage was forced to seek an outlet in that direction, digging large channels into the soft deposits of the base which are now occupied by Nine Mile creek and North and South Beaver creeks, and pouring mighty floods, especially during the time of the melting of the ice, upon this feebly developed portion of the Altamont moraine, thus removing it almost entirely.

The northern and southern members of the moraine are far better developed, the till with its sand "pockets" and the underlying sands and gravels forming the bulk of both ridges. The loess, as already mentioned, occupies the flat back of the northern ridge, while in the "Canton ridge" it is more restricted to the southern slope.

What caused the glacier to spread laterally to the east as soon as it reached the latitude of 43° 30′ N., was evidently the upper portion of the underground quartzyte-ridge, clad and flanked, to some extent at least, by later Mesozoic rocks and rising more or less abruptly above the Tertiary plains, thus giving way to the tendency of the ice-sheet to extend also laterally at about the point where we have now the northern limit of Lincoln county.

In the southern part of the region we meet with a similar phenomenon. As seen on the map, the "Canton ridge" suddenly changes its direction at a point cut by the 96° 40′ meridian, and, trending westward for about 7 miles, forms an angle of nearly 90°. The circumstance that in about that neighborhood, as already mentioned, a very firm, "flint like" sandstone has been revealed by boring at a depth of about 100 feet, probably underlain by the same red Sioux quartzyte as found in the north, suggests that also here the quartzyte, flanked or entirely covered by hard sandstone, rose probably as an outlier above its surroundings. The lateral extension as well as the southward movement of the glacier was here arrested, the resistance met with giving rise to a stowing of the material to a hight which even exceeds that of the northern ridge, while the more western portions of the ice-sheet, which were not obstructed by barriers of any kind, proceeded southward, thus continuing the moraine over Beresford in an average direction N.-S. beyond the southern limit of the area.

Standing on the back of the northern member of the moraine, about three miles north of Tea, one is struck by the flatness of the surface that extends, like a narrow swell, about a mile in width, at nearly the same level towards the east, until it turns northward and assumes towards Sioux Falls a rather hilly character. It is discontinued within the limits of the region under discussion at several points, where the waters, discharged from the glacier, had dug outlets into the deposited material. These *outlets* exist in the form of shallow sags with more or less even floors east of the Breckenridge Division of the Great Northern R. R. and west of the Chicago, Milwaukee & St. Paul R. R., and also in the form of a deeper channel, which, about a mile in breadth in its upper level, has cut over 60 feet into the till, thus dividing the northern member of the Altamont moraine into two portions, a western and an eastern one. This deeper channel as well as the shallower sags drained into an amphitheatre-like basin, within the outer slope of the moraine. In the northwestern corner of the area another outlet has been met with, which is, however, not so deep and also narrower, its width amounting to only about half a mile. All these outlets are during the rainy season to a greater or less extent occupied by freshets, the last mentioned by the waters of Beaver creek.

Also the southern member of the Altamont moraine, within the limits of the area, exhibits this feature. Its surface, in which the character of a ridge is better pronounced than in that of the northern member, in so far as it is rendered more uneven by erosion, carrying a number of knolls, which testify to the original hight of the ridge, rising from 200 to 220 feet above the axis of the trough, is more or less cut up by shallow, flat-bottomed and also by deeper outlets, which have assumed in the course of time the form of V-shaped valleys, all of them being now temporarily claimed by the head-waters and tributaries of West Brule creek as well as by the head-waters of a creeklet tributary to the Big Sioux. One sag is met with near the eastern end of the ridge, a little west of the point where the road, coming from the north and ascending the slope, enters upon the back of the terrace-like most eastern end of the ridge, now detached from the latter to some extent by said sag, which, although having attained a breadth of one mile, has become extremely shortened through the agency of Pattee creek as well as of the tributary of the Big Sioux. The waters, discharged by the glacier through this outlet, probably occupied during that time the channel which is now drained by Pattee creek and its tributaries. Three other outlets are to be found within T.96N., R.49W. The middle one, now claimed by the upper course of West Brule creek, is a rather V-shaped valley, the narrow bottom of which lies over 80 feet below the detached portions of the ridge east and west, while the sag, about three quarters of a mile east, is now unoccupied, and the other, a little deeper, which is met with about one mile N.E. of Beresford, is at the present time during the rainy season flooded by a western tributary of West Brule creek. Its width amounts to about three quarters of a mile, while its flat floor lies about 25 to 30 feet below the summit of the Beresford portion of the moraine. The reason why not only the back, but also the southern slope of this part of the moraine has become so much cut up is probably to be found in the greater thickness of the ice-sheet at this point, caused by the stowing of the ice, which, maintaining a slow but strong southern course, suddenly met with the barrier. During successive melting phases it dismissed mighty torrents upon the southern highlands, thus giving origin to the now widened valleys of the Brule creeks.

Besides the outlets there is another characteristic feature of the moraine: the *basins* and *ponds*, which usually occupy the inner slope, but also to some extent the back of the northern member of the moraine. The basins, which were once filled by the waters of the retreating ice sheet and which may have been at that time deeper than they are now, are as a rule small and shallow, covering rarely more than a square-mile of surface, and being partially occupied by ponds, which dry out during a time of lasting drought or hold more or less water throughout the year. They are less developed on the bottom of the trough and near its axis, and the circumstance that they are not at all or at least very rarely met with on the surface and the outer and inner slopes of the "Canton ridge," is readily explained by the great declivity of the inner and the torn-up condition of the outer slope; while the flat back of the northern member as well as the less pronounced inclination of its inner slope furnished more favorable conditions for the formation of these basins.

Another feature, which is not directly connected with the moraine, as it rather indicates a phase of the retreat of the glacier after the moraine had become accumulated, but which might be taken up in this connection, is the *drumlins* met with in the area under discussion. They are low hills, not exceeding 10 to 15 feet in hight, of more or less oval shape and composed of gravels, sands and the "bowlder-clay" of the drift, their long axis lying in the direction of the drift. They are in most cases the accumulation-points of erratics. These are of all possible kinds, although the composition of this material varies. Two of them have been observed by the writer, not very distant from each other, one within and the other without the northern boundary of Lincoln county, within T.101N., R.51W., an imaginary line connecting them and coinciding with their axes, running N.W.-S.E. Another one lies north of the road that leads one mile south of Tea to Harrisburg, within a fourth of a mile west of the latter town. A series of four of about equal hight above the level of Long creek have been met with along the eastern bank of said creek about seven miles south of Lennox, the summits of which are to some extent flattened and covered with the biggest bowlders, seen by the writer within the limits of the area. They suggest a phase of transitionary cessation during the retreat of the glacier and might possibly have formed a portion of a barrier, that at least contributed something to the formation of a *glacial lakelet,* which is supposed to have reoccupied the once abandoned basin of the Pliocene lake. The possible western boundary of this glacial lake has been indicated by Todd on his "Geological Map of a Portion of Eastern South Dakota" in Irrigation Paper No. 34 of U. S. Geological Survey, while its eastern shore line from the 97° on is found approximately given on the map subjoined to this paper. It is the outline of the probable extension of the lake eastward, after it had removed a portion of its barrier.

The *bowlders,* however, although they are found widely distributed over the region under discussion, represent one of the most prominent features of the moraine in so far as they are most frequently found on its summit as well as on its slopes. They are usually more angular in shape than those found in the till, while their size varies from ½ foot to 4 and even 5 feet in diameter. Although there seems to prevail a decided irregularity in the distribution and the arrangement of these erratics, there are points, especially in the northern part of the region, on the back as well as on the inner slope of the moraine, where the bowlders, especially where they cross the road and also in pastures at both sides of the road, can be observed to be arranged in trends, which maintain an average direction from the N.W. to the S. E. or straight north and south. This peculiar arrangement has been indicated on the map. They are crowded on the inner slope and less thickly strewn over the back of the northern ridge, while they are more feebly developed in the middle portion of the region, except on the drumlins, mentioned above, and entirely lacking in the southwestern part of the area, reappearing within the limits of the southern member of the Altamont moraine. Distinct *striation* of the surface has been observed only in one case, viz., on a light yellowish, very hard limestone, 1x1 foot in size, of probably

Silurian age, which was found near the Chicago, Milwaukee & St. Paul R. R. where it crosses the northern boundary of Lincoln county. The striae extend more or less discontinued over the entire smoothened surface of the bowlder. They are not decidedly parallel to each other, but are more or less inclined toward each other, while their depth varies from $^1/_8$ to $^1/_{10}$ of an inch and their breadth from 1 to 3 mm. A list, prepared from collections from several localities, will show their character and may suffice to prove the decidedly northern origin of these erratics, of which many can be traced with a greater or less degree of certainty back to the mountainous regions of Minnesota and possibly farther.

From the northern ridge:

1. Reddish porphyritic granite, 3x4 feet; 2. dark gneiss; 3. a pinkish quartzyte; 4. almost black hornblende schist; 5. gray fine and medium grained granite, the gray being in some cases replaced by a yellowish shade, while the iron pyrite is very conspicuous; 6. crystalline, light yellowish limestone of probably Silurian age, showing impressions of Bryozoa.

From the vicinity of Lennox were obtained bowlders of:

1. A mica-dioryte, porphyritic; 2. yellowish medium grained granite, abounding in mica; 3. a light coarse grained granite; 4. a reddish small grained granite; 5. a bluish gray medium grained gneiss; 6. a crystalline, yellowish gray limestone.

On top of the bluffs of the Big Sioux near Spring creek the following bowlders may be noted:

1. Coarse grained feldspatic granite of a pinkish hue; 2. medium grained granite of nearly the same color; 3. a very firm dark gray gneiss; 4. a light-colored, at places yellowish, firm limestone, showing traces of striation and spicules of sponges and graptolites; 5. a porphyritic dioryte of dark color.

On the drumlins on Long creek have been observed: 1. pinkish and gray coarse and fine grained granites. 2. a medium grained quartzyte and quartz-schist of grayish color as well as of pink shades; 3. a chocolate gneiss; 4. a gray, coarse grained gneiss, showing a jointed structure, 5x3 feet; 5. the red Sioux quartzyte; 6. a gray syenyte with smooth surface, speckled black by hornblende; 7. a light yellow (Silurian) limestone of firm texture, 5x4 feet.

From other smaller fragments a large crystal of a plagioclase may be mentioned, belonging apparently to a basic, porphyritic rock, the axis c of the crystal measuring 1¾ inch, axis b 1½ inch, while angle bc=83° 30'.

The gray granites show in some instances reddish felsitic bands; the gneisses exhibit in some few cases a flexed and bent structure, as though they had undergone dynamic lateral pressure. This may also be said of some talcose and chloritic schists.

Although the presence of these bowlders renders the tilling of certain parts of the region extremely cumbersome, they are in so far of economic importance that they enable the newcomer, whose means are limited, to replace the more expensive bricks by these erratics, in foundations and many structures.

e: *Channels and Terraces of the Quaternary.*

The melting of the "Dakota"-ice-lobe and its retreat from the region under discussion is supposed to have gone on *pari passu* with a gradual submergence of the land, caused by the general downward movement of the surface, inaugurating the Champlain epoch. There is assumed to have existed during the time of the invasion of the region by the ice a subglacial drainage system, when rills and furrows were dug and fed by glacial waters which entered along the inner slope of the moraine as well as through fissures and crevasses in the very body of the ice sheet, and which became better developed when the ice began to melt faster. The most prominent of these glacial channels, as those now occupied by Nine Mile creek and the Beaver creeks, have already been mentioned on a previous page. There are a number of others within the limits of the region, which are now deserted and which are so intimately connected with the members of the moraine that they readily betray their glacial origin. They are as a rule not very deep and not exceeding one mile in their widest portions, while their outlines can be traced with greater or less certainty for longer and shorter distances. More favorable conditions for their development must have prevailed in the southern part of the area than in the north, as they are found more frequently on the inner western slope of the "Canton ridge" than along the inner southern slope of the northern ridge. Only the most prominent are indicated in the map, giving a slight idea of the extension of the drainage system at a time when the Champlain epoch commenced,—at a time of flooded rivers. In the neighborhood of Lennox, however, some channels have been found, which do not seem to have been connected with any of the main water-courses of the region, but which are rather supposed to have drained into the flooded bottom of the trough in the neighborhood of its axis.

The level down to which the entire region finally subsided, and which may be calculated with some degree of probability from the present hight of the upper bowldery terraces, is supposed to have been within 180 and 200 feet below the present level of the Big Sioux and within 80 and 120 feet below that of the axis of the trough.

The *terraces,* which mark the time of the ultimate re-elevation of the region, the so called *"Terrace" epoch,* may be divided into upper and lower bowldery terraces and still lower terraces, on which the bowlders are less frequent or entirely absent, and which on account of their being covered to some extent at least with silt, may be called silt terraces. They have to some extent already been traced by J. E. Todd, while following the trend of the Altamont moraine, and have been referred to by him in U. S. G. S. Bulletin No. 158, pp. 138 and 139. The *upper terraces,* which rise to hights from 160 to 220 feet above the level of the Big Sioux, are to be found near Klondike on the east side of the stream at a hight of 160 feet; a little farther south at even higher levels; east of Canton at about the same level as near Klondike and north of Fairview about 210 feet above the Sioux.

Of *Lower bowldery terraces* may be mentioned one, about 50 feet above the stream, at Klondike, on the Iowa side, another one east of Canton, at a level of about 40 feet, still another one, about two miles west of Fairview, which rises nearly 50 feet above the level of the stream, while a little north of Hudson, on the Dakota side, a terrace rises about 10 feet higher. The *silt terraces* are met with on a far lower level, fro m10 to 40 feet above the stream, as for instance near Canton, where they may be traced with more or less distinctness.

Attention has already been called to the terrace-like topography of the highlands within the southeastern corner of the region.. The highest, extending east of East Brule creek and rising about 220 feet above the level of the Big Sioux, fairly corresponds with the levels reported from the upper bowldery terraces along the Sioux (175, 200, 220, 180 feet). The lower one, east of the former, about 120 feet above the river, within the limits of the lower bowldery terraces (80, 90, 125, 80).

But while terraces were forming along the banks of the big channel which is now occupied by the Big Sioux river, other valleys, more or less distant, but connected with the main channel, were submitted to the same agency, and although the terraces thus formed along the tributaries of the Big Sioux have become obliterated to a greater or less extent, they have been found by the writer fairly preserved at other places, for instance in the sides of the valley of the most northern tributary of Pattee creek, where two terraces were observed, one about 20 feet above the other, the higher rising about 175 feet above the level of the Sioux.

There have been no terraces found of any kind along the Vermilion.

f: *The Alluvial Bottoms of the Sioux and the Vermilion Rivers.*

After having cut down the deposits accumulated in its channel to a depth of approximately 180 feet below the average level of the highlands on the Iowa side, the Sioux river ceased cutting and, meandering from one side to the other, it began to widen its valley. This resulted in the formation of two bottoms, besides the present one. As a rule they are found wherever the banks of the river are developed to high bluffs, but on the other side of the stream. Thus within R.48W. and T.100N., T.101N.; where the banks rise to over 100 feet on the western side, the bottom lands are on the eastern side, about one mile in width. Farther south, from about Klondike to Canton, they are better developed on the western side, while to the east the highlands of Lyon county, Iowa, rise abruptly to a hight of 1420 feet above sea level. South of Beloit the bottoms reoccupy the eastern side, their development west of the stream being hindered by the bluffs of the Sioux, which rise here in more or less bold relief to a hight of 1500 feet above sea level; in the southeast corner of the area they are exceptionally found on both sides of the river, flanked on the west by the lower terrace mentioned above. These bottoms are fairly rich and relatively well settled.

Also along the Vermilion river two bottoms may be noted, more or less equally developed on either side of the stream, their favorable development not being obstructed by bold relief of the topography. They are fairly settled, especially around Centerville.

GEOLOGY UNDER THE NEW HYPOTHESIS OF EARTH-ORIGIN.*

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CONTENTS.

INTRODUCTION.

The nebular hypothesis was not a scientific induction, but cosmic philosophy. Propounded by Swedenborg and Kant, it was given mathematical form by Laplace in a tentative way. It has been called the grandest conception of the human mind, and for the eighteenth century it might have been regarded as good science. It fails, however, to meet the requirements of a modern scientific hypothesis because it does not explain all the facts. But in the absence of any rival theory it has held possession of the field, and has been more generally accepted on insufficient basis than any other conception in scientific philosophy. The time has come for judgment and probable condemnation of the old hypothesis. The formulation of a new and better hypothesis by an honored fellow and former president of this society (Professor T. C. Chamberlin) will be recognized in the future as opening a new epoch in earth-

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science, and as one of the glories of American geology. This is true even if the new hypothesis should not wholly stand.

The critical application of accepted principles of physics to the nebular hypothesis by Professor Chamberlin has revealed its weakness even under direct attack. The planetesimal hypothesis which he has formulated as a substitute seems much better to explain both the astronomical and geological phenomena. It may not be immediately and universally accepted, as it destroys the present foundation of many geological theories, and because the leaders in science are committed to the old ideas; and in all its claims it may not be true. But its main postulate, that the globe was formed by accretion of cold matter, will probably stand.

The purpose of this writing is not to make an extended argument for the new hypothesis* nor to discuss its relations to celestial physics nor even to the solar system, but to indicate its bearings on several problems in geology and very briefly to show how these problems are simplified by the new conception. It is predicted that under the stimulus of the new thought so many changes will be made in our views of geologic processes that the science of geology will be rejuvenated, as its theoretic or philosophic advance has been seriously retarded by its dependence on a false conception of earth genesis.

Comparison of the Nebular and Planetesimal Hypotheses.

The old hypothesis assumes the existence of a mass of incandescent vapor, with or without a nucleus, which by condensation and rotation was differentiated into successive rings; the latter being eventually gathered up into the planets *while still retaining intense heat.* From this postulate there necessarily follows the conception of a cooling earth; and hypogeic geology has been founded on the idea of crustal solidification on a molten globe. The new hypothesis holds that the disseminated planet-forming matter *had lost its heat* while yet exist-existing in the loose form, as rings or zones or wisps of the parent nebula, and that the globular planets were *formed by the slow accretion or infalling of cold, discrete bodies or particles* ("planetesimals").

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* The full presentation of this hypothesis will be given in a new text-book of geology by T. C. Chamberlin and R. D. Salisbury.

The old hypothesis assumes an originally hot globe, with shrinking on acount of cooling; the new regards the globe as originally and always cold at the surface, and the interior heat as the product of gravitational condensation. The old view requires continuous cooling of the globe, while the new allows the conception of increasing internal heat. The old hypothesis makes the earth of largest size at birth and of constantly diminishing volume; the new regards the earth as beginning with a small nucleus and slowly growing by surface accretion, but with large reduction of volume by compression during and subsequent to the accretionary process. The old hypothesis involves the recognition of a primal, heated atmosphere and ocean consisting of the more volatile substances of the earth's mass; the new derives the present fluid envelopes from the earth's interior by a slow process of expulsion due to pressure and heat.

The above brief contrast between the gaseous and the planetesimal hypotheses could be extended, but this will be sufficient to show how fundamentally opposed they are in their application to the origin of the globe. The bearing of the new hypothesis on a number of topics in physical geology will now be very briefly discussed.

Origin of the Atmosphere.

The nebular or gaseous hypothesis requires that the heated globe should be wrapped in the lighter and more volatile substances. The atmosphere and hydrosphere are thereby made coeval with the globe itself. The fluid envelopes must have primarily contained, under high temperature, more or less material which was later given up to the lithosphere. Speculation has been indulged concerning the hypothetical deposits formed by precipitation from the cooling waters; but no rocks which can be referred to such genesis have ever been found. According to this conception the air and the sea are only the residue of the primeval envelopes, although it has been recognized that even under present geologic conditions there is interaction between the lithosphere and its fluid envelopes, with some exchange of material. For example, it seems impossible, under the view stated above, to escape the conclusion that all the carbon dioxide of the present atmosphere, along with that now stored in the rock strata, must have been originally held in the volatile envelopes. The difficulty in the way of harmonizing geological facts with this conception have long been recognized by geologists, but have been reserved for future solution.

The new hypothesis claims that the substance of the atmosphere and ocean were originally a part of the planetesimals, and helped to form the earth's mass. Whether the elements were superficial condensations on the solid planetesimals, like the occluded gases of meteorites, or formed part of their essential substance may not be important to the present discussion. The really important principle is that these substances were world-stuff, and that they were carried into the earth's mass by the accreting process of earth-making. A large portion of the nitrogen, oxygen, hydrogen, carbon, helium, argon and other substances, have been subsequently forced from the earth's interior to the surface by gravitational condensation and the resulting heat. This out-squeezing of the volatile substances has been a continuous process ever since an early stage of earth accretion. But the atmosphere did not exist until the earth had reached a size somewhat larger than the moon; for it appears according to the laws of kinetics and judging from the present naked condition of the moon that up to that size the gravitational attraction of the earth was not competent to hold the gases on its surface. Even to-day the molecular velocities of hydrogen and helium seem to be sufficient to carry the molecules of those gases beyond the earth's efficient attraction. The atmosphere and the ocean of to-day are only such portions of the gaseous emanations from the earth's interior as the earth has been able to hold within its grasp, minus the considerable part which has been restored to the superficial lithosphere by carbonation and oxydation processes.

The atmosphere has had a slow growth, from a probable film of carbon dioxide to its present volume; and the growth is still in progress through volcanic and other exudations, and by release of gases in decay of the crystalline rocks. Throughout geologic time, as recorded in the stratified rocks, loss and supply of the carbon dioxide seem to have been fairly well balanced, as professor Chamberlin and other writers have shown how counterbalancing activities have probably served to check great excess of this chemically active substance on the one hand or its great depletion on the other, and how the ocean has acted as a reservoir and equalizer. In the case of nitrogen, there would seem to have been little loss, on account of its chemical inertness. The relative proportion of oxygen is an interesting question. The suggestion of several writers, including Lord Kelvin, that the presence of free oxygen in the air is due to the action of sunlight on plants, is opposed by the requirement in oxygen of the earliest animal life. The relative intensity of oxydation processes in early as compared with later geologic periods is a new problem under the new hypothesis. Such knowledge as we have relating to geologic climates seems to indicate that the atmosphere conditions of Postarchean time were not radically unlike those of to-day. But the primitive atmosphere must have been very different, as theoretically it consisted of the gases of lower molecular velocities. The carbon dioxide would seem to have been the first of the atmospheric constituents to be retained on the surface of the growing globe. The enlargement of the earth and of its attractive power added the lighter gases to its envelope, and the carbon dioxide has been relegated to a minor place in volume. The active consumption of the gas in carbonation of the crystalline rocks has been a positive reduction of vast amount. The nitrogen has suffered little loss, on account of its inertness, and has become the preponderating element. The amount of water exhaled by the earth has been immense but it has been mostly condensed to liquid, and has always been a small constituent of the atmosphere and locally variable, depending on temperature. It could not freely escape beyond the earth's control because of its easy condensation to a liquid. The quantity of water seems to vary proportionally with the carbon dioxide, as the latter is an independent controlling factor of the atmospheric temperature. This matter will be discussed later under climate. Hydrogen and helium have never been important constituents of the atmosphere because their high molecular velocities have probably carried them beyond the earth's control; although it may be possible that free hydrogen in the air unites with oxygen or other elements.

Under the new hypothesis the atmosphere becomes a subject of geology. Its origin and its history as well as its present constitution are subjects not merely of speculation, but of geologic investigation; and the branch of geology called "atmospheric" will have a much broader field than merely rock-weathering and wind deposits.

Origin of the Ocean.

Like the atmosphere, the hydrosphere is volatile matter pressed out from the lithosphere; and the ocean-making process is still active. In volcanism we see today one conspicuous method by which water is transferred from the interior to the sufrace of the globe. The existence of water in the earth's interior, even in the quartz of the crystalline rocks, has not been sufficiently emphasized. It is not necessary to assume that all the contained water exists as such in the deeps of the earth, as it may be produced in part in the superficial zone by union of the elemnts or by chemical reaction. Perhaps Siemens was right in his conclusion that large quantities of free hydrogen, or hydrogen compounds, from the earth's magma are explosively oxydized in the volcanic chimneys.

The seas could not form until the atmosphere had accumulated sufficiently to hold sun heat that would give the earth a surface temperature above the freezing point. Below this temperature the water which was forced from the earth's interior must have frozen in or on the cold surface of the globe. It would seem as if there must have been a long stage of conflict between the interior heat and the superficial cold. In the early stages of the growing globe the water was forced toward the surface only to be buried under the infalling material of world-growth. Subsequently the pressure and the rising temperature forced it further surface-ward. This idea implies that much of the deeper interior may be comparatively dehydrated, which may help to explain the anhydrous state of vast outflows of molten rock.

It is probable that the moon now represents the preatmospheric stage of world-growth. Under the old hypothesis the moon is supposed to have absorbed its fluid envelopes by interior cooling and resulting porosity; and the earth to be destined for the same fate, on the assumption that the amount of water on the earth is diminishing and the amount in the earth is increasing. The new hypothesis holds just the opposite view. The moon, under the new view, is not an illustration of a globe in old age or of completed evolution, but is an example of arrested development. The moon's growth was stopped by lack of building material before its gravitational power was competent to hold an atmosphere. Its internal heat was apparently sufficient and its volcanic action pronounced, but its gaseous exudations seem to have been lost into space or frozen at the surface. If the planetesimal hypothesis be true in its postulate of world origin and growth then in the moon we may have a visible illustration of an early stage in the process.

The mineral contents of sea water are held by the old hypothesis to be derived from decay of primitive rocks except to whatever extent they were indigenous to the nebulous envelopes. The new hypothesis allows derivation in part from superficial rock alteration, specially the carbonates, but suggests emphatically that most of the saline mineral content of the ocean has been derived, like the ocean itself, from subterranean sources.

EARLIEST SEDIMENTARY ROCKS.

Under the conception of a globe cooling from a superheated state the conclusion seems inevitable that the first deposits should have been chemical precipitates from the ocean of hot water. This idea has been the subject of speculative writing, but no rocks have been found which appear to have had such genesis, although if such precipitates were ever formed they should be discovered somewhere in recognizable form. The conception has been barren of results in petrography.

The nebular hypothesis requires that the globe should have been fully formed before the surface or epigene agencies began their work, and that all the vast deposits of fragmental origin, the clastic rocks, have been wholly derived from the primitive land areas by rock destruction. The new hypothesis allows a different view. "According to this the ocean began its work long before the earth and moon had attained full size by gathering to themselves all the particles of the earth-moon ring or zone. Consequently there were oceanic sediments which were not wholly detrital, but were primitive world-stuff. The earlier ocean sediments must have been deeply buried under the later, and may now constitute part of the interior mass of the globe. It may be that the globe had attained full size before any of the visible clastic rocks were made. With the water on the earth's surface increasing by supplies from the interior and with matter still being gathered in from the exterior, the depressions of the primitive continents were more or less filled by a mixed class of sediments partly from volcanic and partly from the material of incoming planetesimals. Encroachments of the ocean on the continents probably occurred as in later times, followed by withdrawals as the ocean basins sank and increased their capacity. As the decomposition of the clastic material was probably less complete than in later times, from lack of vegetal covering and other causes, the mixed sediments when metamorphosed resembled original igneous rock, and it is now difficult to distinguish the metamorphosed clastics from true igneous rocks."*

With the passing of the old hypothesis it will be desirable to change the terminology of the rocks as far as this now implies an original molten or "igneous" state of the earth. Some new name will be desirable for the sediments which were formed chiefly or wholly from the planetesimals (the cosmic matter) in the early seas of the growing globe. Let us call such deposits *cosmoclastics,* and the primitive massive rocks, the *cosmics.* The downward succession of the rocks would thus be, from unaltered clastics through altered clastics (metamorphics) to metamorphosed cosmoclastics; while beneath these, perhaps ever invisible, lie the altered cosmics, the primitive deposits.

The above theoretical succession of the strata, the slow upward gradation from primitive world-stuff into the differentiated secondary sediments seems in better accord with our knowledge of the deep-seated rocks than the assumptions of the old hypothesis.

VOLCANIC PHENOMENA.

The vast extrusions of molten rock over the earth's surface without explosive phenomena, and the intrusions into the superficial zone known as dikes, sills and laccoliths, may be in harmony with either hypothesis of world genesis, as the main factors seem to be great internal heat, potential fluidity, relief of pressure and hydrostatic equilibrium. However, under the old hypothesis, which favors homogeneity in the interior, it is difficult to see why an outflow of molten rock once begun

* Quoted from LeConte's Elements of Geology, 5th edition, page 299.

should ever cease. But the new hypothesis is more favorable to limited liquidity, since it favors heterogeneity of the earth's mass and consequent local variation in temperature and melting point.

The varied phenomena commonly known under the term "volcanism" are much better explained by the new hypothesis. It is evident that the explosive action in volcanoes is due to the expansive power of heated vapors, chiefly water. Under the old view the supply of water is from the hydrosphere, but the assumption that volcanic water is meteoric is founded mainly in analogy and has little basis in observation or sound reason. We may admit that the water of thermal springs and geysers and perhaps some fumaroles is atmospheric. But the volcanic water is too large in quantity and apparently from too great depths to be derived from superficial sources. The amount of volcanic water is enormous. Fouqué determined that the amount of steam expelled from one of the numerous parasitic cones of Etna was equaled in 100 days to 462 million gallons of water. This equals 16 gallons for every square foot of a square mile, or a depth of 32 inches over that area. But the steam product of the single cone was probably not the one thousandth part, perhaps not the one ten-thousandth part, of the whole product of the volcano during that time.

The interstitial water of the rocks can not be sufficient to product the vast accumulations localized in the volcanic reservoirs, and efficient circulation at great depths seems impossible. The capacity of molten magmas to absorb vapors has been used as an argument for the meteoric source of the water, but an objection is that before the water can reach the absorbing magma it must pass through a great thickness of moderately heated strata where the repulsive force is great and the absorbing power is small or entirely wanting. The idea of supply through fissures, subterranean or oceanic conduits, in the face of the vastly superior and opposing hydrostatic pressure of the molten rock is not worthy of consideration.

The presence of water and other gases in the crystalline and deep-seated rocks is a familiar fact to petrographers, and the theory that the volcanic waters were indigenous to the earth's magma has, in later years, been held by several students of volcanism, for example, Scrope, Fisher, Reyer, Tschermak and Stübel. Nearly ten years ago the view was emphasized before this society by Dr. Lane,* but the repressive effect of the old hypothesis has prevented the full recognition of the truth and of its value. However it has not been shown how, under the nebulous condition of the globe, the molten nucleus could obtain a grasp on its occluded gases.

The new hypothesis simplifies the problem not only by making the volcanic water and the accompanying vapors indigenous to the earth's mass, but by giving a plausible explanation of how they came to be a part of the magma. Volcanoes are at once the outlets for relief of accumulated vapor pressure and a source of ocean and atmosphere supply. With the reduction in volume of steam and the lighter gases the heavier and nonexplosive gases become more evident, and then occur the later phenomena known as fumaroles, solfataras, soffioni and mofettes. It may be that in the volcanic reservoirs the several vapors are arranged, as in the atmosphere, according to their specific gravity.

The existence of carbon dioxide springs (mofettes), such as the "dog grotto" near Naples and the "valley of death" in Java, are well explained under the new hypothesis. Under the old view the mofettes were compelled to derive their carbon from limestones and carbonaceous shales. The dog grotto with its strong and continuous flow for some thousands of years, probably, would imply a subterranean limekiln of immense extent. Shales could not furnish the supply as they are not sufficiently permeable. This topic will come up again in discussion of the hydrocarbons.

The chlorides and other haloid salts in volcanic emanations have been assumed to come from sea water or from marine sediments where the sea had left them. The variety of gases in volcanic eruptions can not all be derived from atmospheric water, and some of them are not contained in sea water. The abundant sulphur compounds have not been accounted for at all. The resemblance of the mineral contents of the sea to the volcanic products lies in the fact that the ocean is itself the product of volcanism. The old view has put the effect for the cause.

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* A. C. Lane. "Geologic activity of the earth's originally absorbed gases." *Bull. Geol. Soc. Am.*, vol. v, pp. 259-280.

The existence of volcanoes remote from any water body, and in arid regions, is not a difficulty under the new hypothesis. The comparatively nonhydrous condition of the molten rock in many outpourings is not entirely clear, but it is less a difficulty under the new hypothesis, since this does not favor homogeneity in the earth's mass nor uniform distribution of the volatile matter. The possible comparative dehydration of the deep interior of the earth has already been noted. Moreover, there is as it would seem, greater opportunity for localization or concentration of the volatile matter under the new than under the old hypothesis, because of greater porosity of the earth's mass.

The theory of primogenial water-substance and other vapors under the new hypothesis does not at once sweep away all the difficulties and mysteries of volcanism, but it gives a more rational philosophy of the matter and a good degree of unity to the phenomena. Let us who have been trained under the old hypothesis be on our guard in discussion of the new theories that our arguments or objections are not derived from or based on the old views. A new view-point is necessary to get the right perspective of the old problems.

SOURCE OF THE HYDROCARBONS.

It has already been said that under the old hypothesis not only the carbon dioxide now in the air, but all the carbon stored in the stratified rocks must have been in the primal atmosphere. The withdrawal of the carbon from the air and the storing of it in limestone, coal and petroleum was formerly regarded as a divine process of purification, thereby fitting the globe for habitation by man and at the same time providing him with fuel. Geologists have long recognized in that view a serious difficulty, for such immense quantities of carbon dioxide have been withdrawn from the air since the advent of air-breathing animals that it is doubtful if its full presence in the atmosphere at one time is consistent with aerial respiration. By far the larger part of the stored carbon is in post-Cambrian strata, and a large portion in post-Paleozoic strata. The amount of carbon fixed in the stratified rocks has been variously estimated at from 20,000 to 200,000 times the present content of the atmosphere. The geologic evidences as to climate and life in Paleozoic time are decidedly unfavorable to the idea of a densely carbonated atmosphere. This point will reappear later in this paper.

Another serious difficulty under the old hypothesis is the accounting for the large deposits and localization of hydrocarbons, and their associations with volcanic phenomena. It seems probable that the carbon dioxide of limestones is atmospheric or immediately oceanic. (There may be doubt as to the organic origin of all limestones.) It seems plausible that the hydrocarbons of shales were also organic. From this it was not a long step (though a false one) to the assumption that all the masses of bituminous substances, under whatever conditions found, had been derived from the shales or limestones, and were primarily organic. The organic origin of all the hydrocarbons has been generally accepted in some vague way, but in the application of the theory many difficulties have been met, and the literature of the subject teems with doubts, interrogations and admissions of ignorance. A recent hypothesis holds that the carbon dioxide of volcanic association is produced by the action of meteoric water on imaginary metallic carbides in the earth's interior.

The facts and phenomena relating to the occurrence of the hydrocarbons which have no good explanation under the old hypothesis are given a rational and consistent explanation under the new. Like the substance of air and ocean the materials of the hydrocarbons are all primarily derived from the earth's interior, and the great localizations of bituminous matter, specially in volcanic districts, are probably of immediate derivation from subterranean sources. A few of the facts which discredit the organic theory and confirm the volcanic theory may be marshalled as follows:

1. The occurrence of great quantities of graphite in ancient gneisses and in eruptive rocks.

2. The occurrence of liquid carbon dioxide in the crystalline rocks in notable quantities.

3. The general occurrence in great abundance of hydrogen and hydrogen compounds in volcanic emanations; the same being true of carbon dioxide.

4. The frequent occurrence of mofettes or carbon dioxide springs, with constant flow, prevailingly in volcanic regions. Enormous quantities of this gas are exhaled in some localities.

The "death valley" in Java and the "grotto del cane" near Naples have already been mentioned, and many other examples could be cited. Bischof estimated that the volume of carbon dioxide evolved in the Brohl Thal amounted to 5,000,000 cubic feet, or 300 tons, in one day.

5. The immense deposits with extreme localization of petroleum, as at Baku, and of asphaltum, as in Pitch lake, in regions of volcanism.

6. The association of petroleum with heat and solfataric action, as in Louisiana, Texas and California.

7. The occurrence of solid hydrocarbons, as gilsonite, ozocerite, albertite, etc., in vein systems like ore bodies, and reaching to great depths.

8. The capricious occurrence of gas and oil in all geologic horizons, and usually with no clue to their derivation.

9. The localization of oil or gas in strata which are otherwise barren in the same material; thus proving its foreign origin.

10. The failure to discover any rocks which have certainly lost a carbonaceous content.

Here are only ten counts in an indictment which could be extended. Doubtless there are hydrocarbon accumulations from organic sources. Like other natural products their origin and history are complex. But if the organic theory applied truly to all the hydrocarbons it should explain the facts, while most certainly it does not; and the theory has been a hindrance to the study. It is time that the geologists ceased to grope in the darkness of this inadequate theory. The volcanic theory seems to fairly explain the essential facts, and it should be placed on trial. The close association of hydrocarbon accumulations with volcanic phenomena is a very striking and important fact, although generally ignored. It illustrates the repressing affect of a wrong theory, when once established.

It will be seen that under the new hypothesis the geologic processes are not made more simple, but instead are given greater complexity. The hypogene forces are brought into present intimate connection with the epigene agencies. In other words, to the complex processes operative on the surface of the globe there is added a widely distributed and presently active volcanism. This added complexity is only what should be expected in the growth of any branch of earth science, even if not wholly welcome.

GENESIS OF METALLIFEROUS DEPOSITS.

The commonly accepted explanation for the deposition of most vein ores is by the work of heated ascending waters or other vapors. Under the old view the water is meteoric and is made to descend against the same forces that cause it to rise. The new view simplifies the process by regarding the vapors as originally resident within the depths of the earth, and seeking escape from the rising pressure and heat. The formation of ore bodies is to be regarded as a part of the general process of expulsion of the soluble and vaporizable materials from the earth's interior by heat and pressure.

ORIGIN OF GYPSUM AND SALT DEPOSITS.

The suggestions under this topic are offered tentatively and as illustrating the radically different viewpoint of the new geology.

The old theory holds that the sodium chloride has been produced as a secondary product, resulting from decay of sodium-bearing minerals and reaction with chlorides; except to the extent that it was contained in the primal vapory envelopes of the molten globe. The ocean is thus made the immediate source of all the sodium chloride, and the deposits of rock-salt are supposed to be produced directly by evaporation of sea water, or derived indirectly from the ocean through diffusion in marine sediments and reconcentration in salt lakes.

Under the new hypothesis the salt and gypsum or their constituents are indigenous to the earth's mass and at least in part are derived, like the ocean itself, from the interior of the earth. They are certainly contained in volcanic emanations and doubtless may have the same source. But we may venture another step in our theorizing and question whether some saline deposits may not be accumulated directly by the eruptive processes.

It is certain, being a matter of present observable process, that some salt and gypsum deposits are produced by evaporation of saline waters, and it is therefore a legitimate theory that all similar deposits have the same origin. But some salt deposits are so thick and pure and so localized that no satisfactory explanation has been given of the formative conditions under the evaporation process. The Stassfurt deposits are some 1209 feet in depth and the lowest beds holds 625 feet of pure salt. At Sperenberg, near Berlin, the deposits are said to have been pierced 4200 feet without reaching their base. At Wielcza the salt deposit is 4600 feet thick. A mass of salt is described at Parajd, Transylvanit, with length 7550 feet, breadth 5576 feet and depth 590 feet. When we consider that 93 per cent. of the volume of sea water must be evaporated in order to throw down the salt it is difficult to imagine the physical conditions of either sea or lake which could precipitate such localized masses in such pure state. The remarkably deep and pure deposits at Petite Anse in the Mississippi delta are still unexplained.

Salt masses sometimes contain inclusions of hydrocarbons, hydrogen, carbon dioxide and nitrogen, which strongly suggests the association found in volcanic emanations.

The aridity of climate necessary for the production of salt deposits by evaporation must be taken into account; and salt masses are found in strata as far back as the Cambrian. This fact seems positively inconsistent with the factors of climate required by the old hypothesis, as will be noted later.

It may be possible wholly to explain the salt deposits under the evaporation theory, but if so it is time it were done. The delay and difficulty suggest the wisdom of trying a new line of attack.

GEOLOGIC CLIMATES.

While climatology is immediately a province of meteorology, under the new hypothesis, which we are favoring, not only the origin of the atmosphere, but its subsequent changes in composition, producing climatal variations, are due to geologic processes. The new geology involves a new meteorology. Instead of the highly carbonated atmosphere and tropical climate of early geologic time, according to the old hypothesis, with slow decarbonation and cooling, culminating in the refrigeration of the present day and pointing to a "final winter," we shall regard the past climatic conditions as not radically unlike those of the present. We shall recognize that throughout geologic time there have been such variations in climate, periods of cold and aridity or of heat and moisture, as we know have occurred since the middle Tertiary. The paleontologic evidences bearing on ancient climates need to be reviewed in the light of the new meteorology.

In this connection it should be stated, as an interesting matter of history, that the planetesimal hypothesis was developed by professor Chamberlin as an outgrowth of his studies in glaciology. He found the best explanation of Pleistocene cold to lie in the quantitative variation of the atmospheric constituents. This led to the consideration of the origin of the atmosphere, which naturally involved the genesis of the earth as well as its fluit envelopes. It is a striking illustration of the unity of all earth-science.

As the writings* of professor Chamberlin have so fully discussed this subject the present writing will give only the brief statement necessary to the purpose of this paper.

Oxygen and nitrogen are transparent to "dark heat," while carbon dioxide and water vapor intercept and store it. The thermal properties of the atmosphere are chiefly due to this property of these two gases, which are least in quantity of the important constituents of the air, the carbon dioxide forming only one three-thousandths part; but on account of their thermal potency and their small proportion of the atmospheric volume any variation in their quantity produces disportionally large thermal effects. The amount of water vapor depends directly on temperature, so that this gas intensifies the effect, either way, produced by changes in the amount of carbon dioxide. Consequently we may regard the carbon dioxide as the climate-maker, and the important question is with reference to the fact and the cause of its volumetric variation.

The probable derivation of this gas from the earth's interior has already been shown, and it may be assumed that the rate of supply is fairly uniform. The gas is withdrawn from the air by rock decay and organic accumulations and is stored in rock strata and the sea. It would seem that the consumption of the gas could not be so uniform as the supply. Broad land areas of crystalline rocks favor rock decay by carbonation and the depletion of the atmospheric carbon dioxide, while restriction of the land areas reduces the consumption and allows enrichment of the atmosphere. Many other modifying, and even opposing, factors exist; but in the long eras of interaction

* Articles by T. C. CHAMBERLIN in the *Journal of Geology*, vol. vi, pp. 609-621; vol. vii, pp. 545-584, 667-686, 752-788.

between atmosphere, rocks and ocean there must have been established a fair compensating adjustment between removal and supply of the carbon dioxide, though not an exact balance. Any enrichment of the air in this gas gives the atmospheric blanket greater power to retain the sun heat and produces warmer and more uniform climate, with greater moisture. Depletion of the carbon dioxide makes the air more transparent to reflected heat, the blanket is thinner, the temperature falls, the moisture decreases, and areal or zonal differences of climate are intensified because the obliquity of the sun's rays become a greater proportionate factor.

Extreme and rapid climatic changes can not occur for the reason that causes act slowly while effects lag, and counterbalancing factors as checks come into play. One of these checks is the ocean, which serves as a great reservoir of carbon dioxide, containing some eighteen times as much as the atmosphere. On depletion of the atmospheric carbon dioxide the ocean by diffusion yields of its supply and thus helps to bring back the normal balance.

If this theory of climate be true it will harmonize with geologic facts. Let us make a tentative application. The great land elevation and expansion, with mountain formation, of Tertiary time was accompanied, at least in the earlier periods, by warm climate even in the arctic region; but it was followed by Pleistocene glaciation. The very remarkable glaciation found in Permo-Carboniferous strata of middle and southern latitudes followed the land expansion of the later Paleozoic and the formation of the Carboniferous coals. These two series of events seem quite clear. If other epochs of glaciation are found we may expect that they will have succeeded eras of broad expansion of new lands, or other causes of carbon dioxide depletion. Seasons of aridity, with possible production of salines, are also the effects of impoverishment of the atmosphere in carbon dioxide and moisture in less degree, perhaps, than required for glaciation; but aridity will usually accompany glaciation since both classes of phenomena imply unequal distribution of precipitation. Prevailing red color of the rock strata may also indicate comparative aridity. Seasons of warmth and moisture, with luxuriant plant life, should be found to follow eras of transgression by the sea and quiescent conditions.

Professor Chamberlin has shown how submergence of the continental borders favors limestone accumulations which in turn causes enrichment of the ocean and air in carbon dioxide, since the limestone fixes only one equivalent of the carbon dioxide, and releases one of the water, from the bicarbonate held in solution. For example, the warm and probably moist climate so widespread in the mid-Carboniferous followed the long submergence and limestone-making of the sub-Carboniferous; and that of the Tertiary succeeded the limestone deposition of the Mesozoic and Eocene.

If the salt deposits of the Cambrian and later time are an evaporation product then certainly the atmosphere of those early times did not contain the carbon dioxide which has been stored in the later strata. These two sets of facts, the vast quantities of stored carbon and the ancient salt deposits are discordant under the old hypothesis. The new hypothesis on the other hand gives a satisfactory explanation for both classes of phenomena.

GLACIATION.

It is beyond the plan of this paper to discuss at length the phenomena of glaciation under the new hypothesis, since it has already been traversed by our leader in this field. Briefly it may be said that glaciation is not the remarkable and unusual phenomenon it was once thought to be, but may have occurred even in early geologic time. The conditions, geologic and meteoric, requisite for glaciation do not seem to be extraordinary. Glaciation is essentially a local phenomenon, a fact which was not formerly appreciated. Cyclonic circulation of the atmosphere, which localizes and concentrates the precipitation, with just sufficient cold to produce snow instead of rain, may initiate a snow field, the perpetuation and extension of which is an ice body. A cause of general low temperature would seem to be the reduction in amount of atmospheric carbon dioxide. The extent and altitude of the land masses probably have an indirect influence by determining the great barometric areas and the paths of cyclonic storms. It is possible that the attitude of the earth toward the sun may have some effect and that the precession of the equinoxes might, at a critical time, help to produce the alternation of glacial with interglacial epochs. It is probable that glaciation is not a simple effect, but the product of the interaction of several factors, atmospheric, geologic, geographic and astronomic, and all these so delicately balanced that any slight change may cause great effects.

We are living in a glacial period. The waning glaciers of the Pleistocene are still found in every quarter of the globe. But within a generation the northern glaciers have shrunk in conspicuous degree, although the metorologic data have given no certain hint of climatic change. It may be that decrease in snow fall is a greater factor in the shrinkage of the Alpine and Alaskan glaciers than increase of temperature. And it is probable that climatic changes which would be competent to produce a rapid growth of the existing glaciers might occur and yet be so imperceptible as to be undetermined by less than a century of accurate observation.

DIASTROPHIC MOVEMENTS.

That mountain systems have been formed by lateral or tangential pressure and consequent crumbling of the strata is a fact of observation. The apparent cause of the mountain-making compression is shrinkage of the globe. Under the nebular hypothesis a difficulty is here met which has never been squarely faced, but like so many other contradictions of facts by the old hypothesis has been neglected in the hope that sometime, somehow the explanation would be found. The amount of tangential compression which the physicists allow to the crust of the cooling globe is insufficient to account for theactual shortening which has occurred in the making of the many mountain systems. Mallet estimated that the earth had shrunk from the molten state 189 miles in diameter, a circumferential reduction of less than 600 miles, and most of this must have taken place during solidification and in the stages of high temperature. But nearly all the great existing mountain systems have been formed since later Paleozoic time, since which time the secular contraction must have been very small. Claypole estimated the amount of shortening in the Appalachians as 88 miles, and Heim estimates the same effect in the Alps as 72 miles.

Under the new hypothesis the earth-shrinkage is due to original porosity and gravitational compression, and is in active operation today. The amount of such spacial reduction has not been estimated, but it must be several times any possible reduction due to cooling. The ocean represents elimination of interstitial space; so does the atmosphere, condensed to solid or fluid; and also the unknown but enormous amount of gaseous material which has escaped from the earth's control. To the contraction represented by this vast amount of out-squeezed material must be added the condensation of the interior mass as absolute molecular compression without extrusion of matter. This latter factor in the shrinkage of the globe is the only one which the old hypothesis can recognize.

The new view not only favors much greater amount of contraction in the globe but makes the rate of contraction more uniform throughout geologic time.

To whatever degree the lateral compressive strain in the earth's surface layers may be due to insertion of wedges of igneous intrusives the new hypothesis is as favorable as the old.

The up-and-down (epeirogenic) movements of continental areas are difficult of present explanation under either hypothesis. They would seem to have readier solution under the hypothesis which favors greater movement in the mass of the globe. The new hypothesis would also seem to be more favorable to changes produced by the invasion of the cold superior strata by heat from beneath. And the several possible requirements of viscosity or mobility, or potential fluidity of the interior mass are equally well met by the new hypothesis.

With the passing of the discredited nebular hypothesis, substitutes should be found for the misleading terms "crust," "nucleus" and "igneous."

Irregularities of the Earth's Figure.

Although much has been written on the subject of continental forms, and even geometric and crystallographic principles have been applied, yet it must be admitted that no clear meaning has been found for the relief forms of our globe. Perhaps if the efforts had not been made under a false conception of earth genesis better results might have been attained. It seems likely that the relief forms are fortuitous, due to irregular accretion and unequal density, and that they have no genetic or structural relationship. This conclusion is strengthened when we consider that the configuration of the exposed lands is greatly changed by relatively small differences of vertical position; and even more important, by the almost certain fact that the disposition and relation of lands and sea have been in former ages radically unlike the present. This latter fact does not entirely contradict the principle of relative permanence of the continental and oceanic areas, but suggests that the principle must not be applied too rigidly.

Investigations seem to prove the unequal density of the earth, and the same conclusion is reached by physical deduction. The fact of epeirogenic oscillations and orogenic uplifts would seem to imply that under slowly applied and long continued forces the deeper rocks of the globe are viscous. This seems to require isostatic equilibrium; which in turn implies that the sub-oceanic portions of the lithosphere must be denser than the continental areas; and that the lithosphere of the southern or oceanic hemisphere must be denser than that of the northern or continental hemisphere. These conclusions as to the varying density of the earth may not be wholly contradictory to the nebular hypothesis, but they are certainly more favorable to the new hypothesis. Long duration of gaseous and liquid stages in the life of the globe would favor diffusion, convection and resulting homogeneity. The new hypothesis, forming the globe from cold solid materials, favors heterogeneity, and is in better harmony with the geologic facts and the philosophic deductions relating to the earth's structure.

Life on the Earth.

Under the new hypothesis the problem of the origin and duration of life may be quite a different matter from the same problem under the old hypothesis. With the high temperatures required by the nebular hypothesis, life was at first impossible, and the low temperature of space has seemed to prohibit the importation of life germs from abroad. This placed a limit to both the origin and the duration of life on the planet. Recently the announcement has been made that the extremely low temperature of liquid hydrogen is not fatal to life germs. This being true it not inconceivable that germs might endure the cold of celestial spaces, and might reach the earth by way of meteorites; or even that they might have existed on the planetesimals of the earth-moon zone or ring.

A much less speculative thought is this,— that under the planetesimal hypothesis the ordinary conditions of temperature and moisture requisite for life as we know it were probably fulfilled long before the planet attained full size. The duration of life on the earth may thus be thrown far back in time, and the slow processes of biologic evolution are given far greater duration for their outworking. The limits of geologic time fixed by the physicists on the premise of a cooling globe have no application whatever under the new hypothesis, and the biologists and geologists are released from any time restrictions hitherto imposed.

Conclusion.

The mathematical and physical speculations based on the conception of a cooling globe are unreliable and misleading. The recognition of this truth will release geology from its undue deference to authority. Geologists have not had sufficient confidence in the inductions of their own science, but have deferred too much to the philosophic deductions and speculations of the physicists and mathematicians. Scientific men in general, seem to have an almost superstitious regard for mathematical results. The geologists have not properly realized that all such conclusions relating to geophysical problems if based on assumed data and unknown conditions are not entitled to any respect when they contradict observable phenomena or even sound geologic theory. For illustration: in the face of the abundant geologic evidence or argument for extreme age of the earth, geologists pare down their estimates because mathematical authorities figure out from hypothetical conditions and assumed data, based on the nebular hypothesis, that only a certain number of years can be allowed for the geologic history of the earth. Another example: geologists neglect the formulation of a sound theory of the hydrocarbons because the prevailing ideas of earth origin require that they should be meteoric and organic. Geologists have been too generous in allowing other people to make their philosophy for them.

One of the characteristics of the new geology will be the greater and proper confidence with which its devotees will stand on the basis of their own observation and induction and decline to entertain hypotheses at variance with their own science. Another quality will be insistance on satisfactory theories for observed phenomena, instead of resting in old conceptions which do not explain, or even may be in opposition to the facts. A difficulty in the past has been that physical geology has deferred to a hypothesis of earth-genesis which was not good theory, nor even a scientific induction, and which has been a hindrance and a burden on the progress of earth-science.

The geology of the future will be made by geologists and not by the philosophers; and the study of planetary conditions will have one foundation in geology, as it is here that the science of worlds has an observational basis. The new geology is, even today, modifying the old astronomy. The student in cosmic science must have his feet on the earth even if his head is among the stars.

EDITORIAL COMMENT.

THE EVOLUTION OF CLIMATES.*

This paper, in its enlarged form, and now published by the author, contains essentially the facts and deductions that appeared in this magazine four years ago (August to October, 1899), under the same title, and in his previous paper (The Laws of Climatic Evolution, AMERICAN GEOLOGIST, Vol. 23, pp. 44-57, Jan. 1899).†

Synoptically stated, the author's hypothesis involves the following fundamental ideas:

1. The original primary heat of the earth was sufficient and was so conserved as to determine the climates of the earth and make them uniform from pole to pole during the geological ages until the Glacial epoch.

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* "The Evolution of Climates" by MARDSEN MANSON, revised, enlarged and reprinted from the AMERICAN GEOLOGIST, pp. 86, with 9 plates, August, 1903.

† Earlier papers by the same author, presenting his first discussions of this subject are the following: Physical and Geological traces of permanent Cyclone belts. *Transactions of the Technical Society of the Pacific Coast*, vol. viii, No. 1; The cause of the Glacial Period, and an explanation of geological climates. *Ditto*, vol. viii, pp. 3-21. Read Sept. 14, 1891; Geological and Solar Climates; their causes and variations. A Thesis, *Geology and Physics, University of California*, May, 1893; Circulation of the atmosphere of Planets. *Trans. Tech. Soc. Pacific Coast*, vol. ix, No. 5, Jan., 1892; Cosmic character of the Ice Age, *Glacialists' Magazine*, vol ii, Nos. 5 and 6; The cause of the Ice Age and Geological climates. *Trans. Geol. Soc. Australasia*, vol. i, part 6. Preliminary paper to the Seventh International Congress of Geologists: in French. Read by title, 1897; The laws of climatic evolution. British Association for the Advancement of Science. (By request of Prof. Judd), 1898. This subject was discussed mathemtically by T. HOPKINS, *Jour. Geol. Soc*, vol. viii; also *Phil Trans.*, 1857, p. 805. This was one of the early calculations of the effects of secular heat on the climates of the earth. In 1864 PROF. E. FRANKLAND, F. R. S., advocated earth-heat as a climatic factor. *Phil. Mag.*, May, 1864; also SARTORIUS VON WALTERHAUSSEN. During the latter part of the eighteenth and the early part of the nineteenth centuries HUTTON and WERNER held similar views, but these have been abandoned as untenable. (See *Glaciers*, SHALER and DAVIS, p. 70, and Climatic changes of later Geologic Times, WHITNEY, p. 261).

2. That during this time of earth-controlled climate, the direct rays of the sun were shut out from reaching the earth by a surrounding mantle of clouds of aqueous vapor produced by the evaporation of water from the heated earth; solar energy promoting a conservation of the planetary supply.

3. That as the earth became cooled, land masses, by reason of low specific heat, lost their heat first. The cloudy envelope was attenuated and finally dissipated admitting the sun's rays and inaugurating the present system of sun-controlled climates.

4. That this change took place after the earth's surface and the water of the oceans had reached a very low average degree of heat. The oceans ceased to give off a sufficient amount of watery vapor to form the cloudy envelope after the lands had cooled so low as to become extensively glaciated.

5. The difference in specific heat and in the rate of cooling between the land and the water of the earth, while causing the glaciation of the lands, did not act sufficiently long to cause the congealation of the oceans. It was interrupted by the advent of the sun's rays and the inauguration of the present zonal system of solar climates.

6. Since the inauguration of solar or zonal climates, there has been an increase in the average temperature of the earth's surface, (1) by absorption of heat derived directly from the sun; (2) by the trapping action of the atmosphere upon the long wavelength rays of heat emitted by the warmed planetary surface; and (3) by convection currents which have distributed more evenly the heat thus accumulated. This rise in temperature is most notable in tropical and temperate latitudes, and it has caused and still continues to cause the retreat of glacial conditions in all latitudes.

7. That the gradual transition from earth control to sun control was the epoch of the ice age, although the climates of tropical latitudes probably felt some of the effects of this transition prior to the culmination of the ice age.

Some of the previous treatments of this great problem in terrestrial physics have wandered so far from certain established and fundamental principles, or have been based upon assumptions which apparently disregard these principles, that the author has evidently been particularly careful to bring them forward and to base his presentations and arguments thereon.

At the same time the more recent determinations of the solar constant and of the absorbing and trapping powers of the atmosphere, and its several constituents, have been made full use of.

Objections have been raised against Mr. Manson's hypothesis, some of which may be mentioned, viz:

1. Glacial conditions alternate from pole to pole instead of being uniformly distributed and cotemporary north and south of the equator. To this, Mr. Manson replies, or might reply: that it is not proven that the poles are alternately glaciated. The present shows rather that both polar regions are glaciated. The somewhat greater approach toward sea-level of glaciers in the southern hemisphere than those of equal latitude in the northern hemisphere can be attributed to the low specific heat of greater land areas in the northern hemisphere, compared with the higher specific heat of greater ocean areas in the southern hemisphere.

2. The hypothesis assumes that elevated areas have been everywhere glaciated, even within the tropics. Whereas it is widely known that there is a district morainal belt crossing North America from New England to British Columbia that marks the limit of continental ice-movement, from the belt of north temperate rains, and that a corresponding, but less definitely marked, belt, crosses about latitude 65° N.

It is replied that the morainal belt and other older belts, have outer *fringes,* so-called, which mark earlier, greater extension, and that authorities are not agreed as to the non-glaciation of the tropical zone. Throughout much of the great plains of the west, in Utah, Nevada and southern California, are gravels and tills and terraces identical in composition and in structural posé with glacial formations that lie north of the great morainal belt. Such formations were not, probably, connected with an ice-sheet that had a sweep of continental extent, forming a continental moraine, but they may have been deposited by, or at least due to ice-accumulations that were locally even thicker than the well-known continental sheet. Such deposits can be traced, though with feebler manifestations, much further south, and have been described even in tropical latitudes, and referred to the ice age. Until much more is known of the Quaternary in southern latitudes, it can hardly be held adverse to Mr. Manson's theory, that southern glaciation has never taken place. In the light of the enormously long period of time embraced in the Quaternary, as lately brought out by studies in Iowa and Kansas, it may be inferred that the oldest glacial deposits are no longer recognizable, because of decay and re-deposition. Again, it is held by Mr. Manson that considerable areas escaped glaciation at sea level, especially in tropical latitudes where the sun's rays first pierced the envelope of clouds, and also in elevated regions east of extended Tertiary lava fields.

3. The occurrence of salt and gypsum beds in the older rocks, has been taken as evidence of rapid evaporation under solar energy and this would hardly allow the existence of an earth-mantling cloudy envelope. But this inference is hardly justifiable. Such rapid evaporation, or slow and long-continued desiccation, may have taken place under the action of earth heat as readily as under solar heat, and deposition would take place without extensive evaporation, from the cooling of saturated solutions of these salts or by the mingling of solutions which would cause their formation in excess of saturation.

4. It is now well established that glacial deposits exist in the Permian and other formations, indicating that earth-heat had waned at that date so that glaciers existed. Hence the Pleistocene glaciers could not have been due to the secular cooling which dissipated the assumed cloudy envelope.

Mr. Manson, while admitting the evidence of Permian glaciation in East India and Africa, considers such glaciation as fragmentary, local and meager, and not shown to be extensive enough to prove the occurrence of a wide-spread ice age in Permian time. These phenomena are confined practically to the borders of the Indian ocean. If they have been correctly interpreted, they indicate a curious contrariety of climates, viz: ice action in tropical latitudes during eras in which tropical life flourished in circumpolar regions, and ice-action near warm temperate land and sea-life. Rather than accept these contrary conditions as evidence of general glaciation at sea-level, the author prefers to accept them as evidence that some "land masses were thrust up above the then existing snow line," such snow line being independent of latitude, but dependent wholly on altitude. If that inference be accepted, there must have been, since Permian time, a great change in the borders of the Indian ocean, involving the disappearance of the land-formed tills.

5. Total glaciation of the lands and the chilling of the oceans to the maximum density of water (32° F.) would cause the death of all land life and of nearly all marine life. Whereas the life of the present is paleontologically known to be a lineal descendant from pre-glacial ancestors. It may be urged, however, by Mr. Mason, that his presentation of his theory allows not only for non-glaciated regions where life may have been perpetuated, but that his plate (opposite page 68) and statements on pages 74 and 85,* show that the zonal climates which were dependent on the full ingress of the sun's rays below the cloudy canopy, may have begun their action in early Quaternary time, and that the existence of solar warmth began in the latitude of the tropics and progressed poleward through Tertiary and Pleistocene time.

6. It has been assumed that exogenous trees, growing by annual rings added to the outside, prove the action of alternating summer and winter and hence solar climates. Exogens are sparsely found in the rocks as early as Devonian time, and Dr. Sardeson† has called attention to a twisted form of stem exhibited by certain shallow-water monticuliporoids of the Lower Silurian, which he interprets as possibly due to heliotropism, and hence an indication of direct sunlight. If these indications of early solar climate can be explained conformably with Mr. Manson's theory, or a modification of it, certainly a most serious obstacle will be overcome.

Whatever may have been the condition of the immediate surface of the earth, if it was for ages covered by a cloudy canopy, the sun's light and warmth must have been exterior to the canopy and must have acted on the mists of that canopy in a manner similar to the sun's action on modern mists and clouds. Indeed, it may be assumed, reasonably, that the exterior of the canopy was subject to solar control, and probably passed annually through a succession of changes comparable to the solar climatic changes which now annually encompass the earth. The only effect of these climates in the clouds, which

* See also under 2, p. 52, "Elevated continental areas," etc., and (d) pages 67 and 68.

† AMERICAN GEOLOGIST, vol. xxvii, p. 388, "Meteorology of the Ordovician."

may have been distributed in a zonal manner, on the earth's surface, must have been seasonal fluctuations in the rainfall. Indeed, it is quite probable that this fluctuation was felt zonally on the earth's surface, and perhaps induced wet and dry seasons, or wet and dry belts that encircled the earth. At the present time, the seasons of tropical and low temperate latitudes are *wet* and *dry*, rather than cold and hot. The wet season is the season of growth and all exogenous vegetation adds to its diameter another ring. The dry season supervenes and exogencus growth is stopped as effectually as if chilled by the cold of a northern winter. There may have been, therefore, consistent with Mr. Manson's theory, such alternations of wet and dry as to cause the development of the ringed trunk. even in Devonian time.

It was at the opening of the Cretaceous, however, that a great revolution took place. This was physical and organic, and was world-wide. After this revolution, exogenous plants were greatly multiplied. So great was the approach toward modern forms of trees, that most of the exogenous arboreal genera now extant, began then their existence. If exogenous growth requires the agency of direct sunlight, it would be necessary to allow that the sun's light then burst upon the surface of the planet in its virgin effulgence. But these genera, while flourishing under the alternations of winter and summer in the north, are found also in the south, where the seasons alternate between wet and dry. Since tropical forms of planets flourished from the equator to the poles, even into the Tertiary, and since exogeneous plants flourished throughout from the commencement of the Cretaceous to the present, it is evident that exogenous growth is not wholly dependent on the alternations of summer and winter, such as now characterize the north temperate zone. But some cause became operative which expelled tropical plants from the poles. Whatever that cause was, it did not determine the life and distribution of exogens.

The foregoing objections may require some modification in the application of the theory of Mr. Mason, but they are apparently not fatal to it. So far as can be judged by the writer, the cause of the ice age appealed to by the new theory, has a large and promising element of truth. It has been cautiously accepted by some geologists and cordially received by some physicists and astronomers. The vigor and perspicacity with which it is presented by its author render its acceptance more easy and probable. It is at least destined to take rank among the leading hypotheses of the cause of the ice age, and it must be reckoned with by all who attempt the solution of that standing geological problem. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Geology of Worcester, Massachusetts. By JOSEPH H. PERRY and B. K. EMERSON. Published by the Worcester Natural History Society. Worcester, 1903. 2 maps. 40 plates. 166 pages.

"This book has not been written for geologists. It has been written for the people of Worcester; for those who have no technical knowledge of the subject of geology, and in such a style, we hope, that, taken in hand, it will serve as a guide over the fields and through the streets in the study of the rocks of Worcester and of their relations to one another. But while the book is written for the amateur in nature study, rather than for the professional geologist, we have not tried to slide over, or omit the problems here presented, but to solve them in untechnical language. To the people of Worcester, then, we dedicate this book, hoping that it may b a source of pleasure and profit in their walks about the city."

The foregoing, from the author's preface. is too modest. The book is worthy of being read by any geologist. Worcester presents a great variety of geological structure and of geological and mineralogical problems. The simple manner of treatment does not detract from the completeness of the geological descriptions; and the excellent plates add very greatly to the vividness of the story. The region is Carboniferous. pierced by granite and other intrusives. producing a variety of schists and gneisses. N. H. W.

Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California.. By JOSIAH EDWARD SPURR. U. S. Geol. Survey, Bull. 208, 222 pp., 8 pls., 1903.

In 1899 Mr. Spurr visited Nevada and crossed the state several times from east to west, the primary object of the work being to obtain data for a general geologic map of the region. His routes were planned to cover as far as possible territory not yet crossed by lines of geological reconnaissance, so that the information obtained could be added to that already at hand. The result is a general geologic map, which accompanies this report, of Nevada south of the fortieth parallel and of a considerable portion of adjacent parts of California. In addition to the map the report is devoted to descriptive matter concerning the general geology, the descriptions being grouped about the different mountain ranges. Matters of general and theoretical interest are not included, these subjects having been discussed by the author elsewhere.

U. S. G.

First Biennial Report of the Director of the Agricultural College Survey of North Dakota. Pages 18, with a folded map. Bismarck, 1903.

This survey was organized in the summer of 1901 by the late professor Charles M. Hall, whose first report, here noted, was published after his death. It sets forth the plans which he had made, and portions of the work begun, for surveys of the soils, hydrography, topography, geology, and biology of North Dakota. The accompanying geologic and economic map of the state, on the scale of about 17 miles to an inch, is very satisfactory in its delineation of the drift boundary, moraine belts, highest stage and deltas of lake Agassiz, and basins supplying artesian wells. Much information is also shown concerning the altitude and grand surface features, with approximate contour lines, the average annual rainfall at places where it has been observed during several or many years, and the situation of mines or workable outcrops of lignite coal beds in the extensive Laramie formation, which occupies the western half of the state, and also farther east forms the chief mass of the Turtle mountain on the international boundary.

W. U.

West Virginia Geological Survey, vol II. I. C. WHITE, State Geologist. pp. 725. Morgantown. 1903. $1.50.

This volume is divided into three main parts, viz: Levels above tide; True meridians and Report on coal.

Notwithstanding the interruption which the survey suffered through the failure of the legislature to appropriate means at the session of 1899, Dr White has fully redeemed the survey by the issuance of this fine volume. It was rendered possible by the legislature of 1901, which appropriated money for the survey, and by the patriotic generosity of the state geologist who cast into the general stock of knowledge his private notes accumulated during many years of expert examination in the coal districts of the state.

The recent rapid development of the coals of West Virginia justifies the time and expense of this work. Not only have the commercial coal mines all been visited and sectioned, but average samples of their coals have been collected and subjected to chemical and calorimetric determinations.

Dr White's classification of the Carboniferous system is essentially that published by him in 1891. Bull. 65, U. S. Geol. Survey, and supplements, and extends that of Rogers. It is shown by the following table.

Dr. White remarks: "As will be seen from the foregoing diagram, the line separating the Middle and Upper Carboniferous divisions passes directly through the center of the Conemaugh series. This is

THE CARBONIFEROUS SYSTEM IN WEST VIRGINIA.

	DIVISIONS.	SERIES.			AGE.
Carboniferous System.	Upper: Fres,h or Brackish Water Deposits.	Dunkard, No. XVI. of Rogers.			Permian, or Permo-Carboniferous.
		Monongahela, No. XV.			Coal Measures.
	Middle: Shore Deposits, with Marine Incursions.	Conemaugh, No. XIV.	Upper Half.		
			Lower Half.		
		Allegheny / Kanawha } No. XIII.			
		Pottville, Seral No. XII.			
	Lower: Mostly marine deposits in upper half; earliest coal beds, Impure and of irregular thickness in the Pocono.	Mauch Chunk Red Shale. Umbral		No. XI.	Lower Carboniferous.
		Umbral Greenbrier, or Mountain Limestone.			
		Pocono Sandstone, Vespertine / "Big Injun" Oil Sand. } No. X.			

due to the fact that marine conditions ceased, never to return, in the Appalachian field at least, with the deposition of the Ames, or green crinoidal limestone and its associated beds, midway in the Conemaugh, thus separating it into two divisions, of almost equal thickness, the lower one abounding in marine life, while the upper has nothing but brackish and fresh water forms. The faunal change at this horizon is sufficiently great to warrant the separation of these two beds into two series, but owing to the fact that the moraine type of the Ames limestone is not persistent over the entire Appalachian field and that the lithological characteristics are very similar for some distance, both above and below the horizon in question it is deemed best to maintain the integrity of the Conemaugh formation as modified by the Pennsylvania, Maryland and West Virginia geologists."

The West Virginia survey is in coöperation with the Untied States survey in the construction of a topographical map, after which it is designed to enter upon the detailed geological mapping of the separate counties. N. H. W.

Nebraska Geological Survey. vol 1, Erwin H. Barbour, state geologist. 13 plates, and maps, 258pp., Lincoln, 1903.

"In the preparation of this non-technical introductory report concerning the geology of Nebraska the writer has been actuated by a desire to anticipate the wants of citizens, and to prepare something which may be useful and helpful to them."

Prof. Barbour makes it plain that although Nebraska has not and cannot expect to have valuable deposits of coal and of the precious metals, still that a geological survey posseses great utility for the state. Nebraska has been troubled, like most of the other western states, by mining excitements by which thousands of dollars have been squandered under the specious guidance of so-called "practical miners." The function of a survey is not only to point out natural resources, but also to point out their absence. By the latter many wild schemes that are foisted and fostered by false assayors or by wandering adventurers, can be saved to the citizens of many a community.

This admirable report, while a preliminary one, calculated to open the way for future great extension, is still so complete in its presentation of the present known geological features of the state that it can but be of great service to all who wish to know about Nebraska. It is not only a compend of previous investigation, but also embraces the results of several years of special survey by Prof. Barbour and his assistants. When means are provided it is planned to enter ultimately upon the detailed survey and description of the separate counties in a manner similar to the surveys of Minnesota and Iowa. This can be done the more quickly, as there are numerous topographic sheets located within the state executed by the U. S. Geol. Survey. If this report is an earnest of the future, Nebraska will have when completed a thorough and economic as well as a scientific survey. N. H. W.

On the white chalk of the Tullstorp region and the two moraines between which it is imbedded. An argument in the interglacial controversy. * By NILS OLOF HOLST. (Sveringes Geologiska Undersökning Ser. C. Afhandlingar och uppsatser N:o 194. Stockholm, 1903)

In the region of Tullstorp in Skõne, Sweden, a deposit of white chalk has given rise to a considerable industry. Numerous borings for the purpose of ascertaining the available quantity of this material, but recently made, prove that this chalk is not in place as was formerly supposed by Angelin, Lundgren, Jönsson, Moberg, Dames and others. The evidence furnished by the drift proves it to consist of enormously large blocks, some of which measure 850x300x15 meters, all imbedded in glacial drift.

The country rock is Saltholm chalk, a younger formation than the white chalk. The former, however, is here met with at no less depth than 33 to 70 meters, while the older white chalk comes up within a couple of meters under the surface. This white chalk appears fairly pure and undisturbed. On closer examination, however, it is often found to be fractured into small, cubical pieces, its layers of flint are crushed, beds of clay within the chalk are somewhat flexed and kame and till occur here and there, sometimes these are forced way down into the body of the deposit. More remarkable yet is the occurrence of pieces of antlers belonging to *Cervus elaphus*, the red deer, often seen in the otherwise pure chalk. In two instances these were found at a depth of six meters.

The huge blocks of white chalk rest on the ground moraine and in a few instances they are also covered by the same. Generally, however, they are overlaid by the upper moraine and by fluvio-glacial deposits.

These occurences are coördinated with the much discussed phenomena on the islands of Moen and Rügen and those at Finkenwalde and with the numerous blocks found quite frequently in the glacial deposits of northern Germany. As an analogous formation the author regards the secondary appearance of the Cyprina-clay which, for various reasons, partly quoted from Johnstrup's treatise, he pronounces decidedly preglacial.

Dr. Holst considers his paper an argument against interglacialism, for the following reasons. The white chalk at Tullstorp appears under similar conditions as many of the so-called interglacial deposits, that is those enclosed by two moraines. If such moraines were ground-moraines belonging to two distinct glacial periods, it would be correct to regard the white chalk deposit as interglacial. But the author holds that the lower moraine only is a true ground moraine and that the upper one is an inner moraine issued from the lower portion of the inland ice. The two moraines differ so much in character and structure that if the lower one be regarded as a ground moraine the upper one must be of a different type. He discusses the dissimilarities of

* Om Skrifkritan i Tullstorptrakton och de båda moräner, i hvilka den är inbäddad—Ett inlägg i interglacialfrågan.

the two moraines at great length. Both kinds were observed by him in Greenland. There the ground moraine consists of a clay of bluish-gray color, carrying rounded, frequently striated boulders. The upper or inner moraine bears more angular boulders which are rarely striated, considerable gravel and its clay oxidized at the melting of the ice.

The two moraines found in Germany and Sweden conform to these Greenland moraines. . In Sweden they are found even far northward as well as nearer to the border of the glaciated area. The differences between the two moraines are summarized as follows.

1.—In Germany as well as in Sweden the upper moraine has, as a rule, too insignificant and uniform a thickness to represent a distinct glacial period. It sometimes measures two meters, occasionally from three to four meters, but rarely exceeding the latter depth.

2.—The upper moraine conforms closely to the surface upon which it rests, even though this consist of unconsolidated gravel or of osar and knolls with steep slopes fashioned from this material. It will therefore often reveal the exact form of the under-lying formation. A ground moraine cannot reproduce topographic features.

3.—The upper moraine is not very compact since no inland ice has passed over it. It is frequently poor in boulders and often shows more or less distinct stratification, indicating that water played a part in its deposition. The few striated boulders are derived from the ground moraine. The differences referred to in the last two paragraphs have often been stated by other specialists. James Geikie says: "One may note in many cases that the till which overlies inter-glacial deposits is not infrequently a somewhat looser clay than the generally excessively tough lower till that clings to the rocks underneath. Often too the stones and boulders of the overlying till are, as a whole, less well striated and smoother than those in the bowlder clay below." The latter is said to be "unstratified," the upper one "indistinctly bedded."

Johnstrup also observed the same differences which he considered to indicate a dfferent source for the upper moraine and he attributed its origin to ice floes.

4.—If the upper moraine were a distinct ground moraine, formed by a distinct inland ice then there should exist a definite boundary for this ice and its moraine. But such a boundary, though constantly searched for, has never been found, and it never will be found, because it has never existed. The great chains of terminal moraines represent the most striking feature of the ice age, but this feature interglacialists seek to obscure by directing attention to the two morainees as though they were of distinct origins widely removed in time.

5.—If the upper moraine represented a distinct glacial period preceded by an interglacial stage of long duration, its deposits would abound in vegetable remains and entire forests would be found in them now and then. It is far too thin for burying and covering up, as does the ground moraine, the trees which grew in front of the glacier to which the moraine owes its existence. The intra-morainic sand deposits were intra-morainic from their beginning and formed in this way, viz.: the inland ice, being thin at its edge when gliding out in waterfilled basins dammed up by ice, was lifted up so that the subglacial streams could deposit the sand under the ice and beneath the inner (upper) moraine.

To these deposits belong also the Rixdorf sand the great extent and thickness of which, as well as the peculiar structure of its beds—sand alternating with strata of coarse gravel and layers of boulders with no end of discordancies—plainly indicate that their formation is of glacial origin. And only the mighty torrents issuing from glaciers could have laid down such immense deposits of coarse gravel. The fauna of the Rixdorf sand is a mixed fauna, appears only, or at least mainly, in the coarse gravel and must be a secondary deposit. The study of these sands by W. Wolff and G. Müller has led these geologists to similar conclusions. (D. G. G. Jan. 1902.)

The author believes that this "argument against interglacialism" will prove that the two moraines are contemporaneous. Moraines are the most significant of glacial formations. If they bear witness to but one glaciation then the so-called interglacial formations themselves, if correctly interpreted, can give no other verdict. J. L.

Lecture notes on general and special mineralogy. By FRANK R. VAN HORN, professor of geology and mineralogy in Case School of Applied Science. 683pp., 1903, published by the author, Cleveland.

The preface states that "Owing to the fact that there is no text-book in English, or in any other language which covers a general course of mineralogy, I have decided to publish the series of lectures which I have delivered during the past five years at Case School of Applied Science. * * * The chief faults with most existing text-books are, either that they are not modern, or that one devotes too much time to a certain division with consequent curtailing of others. One will be all crystallography, another all physical mineralogy, while a different one will be devoted practically to descriptive mineralogy." The first part of the book is devoted to general mineralogy, including crystallography, chemical and physical mineralogy; and the second part, to special mineralogy, in which 260 mineral species are described. The two parts of the book are about equal in number of pages; every alternate page is left blank for the insertion by the student of additional notes and figures. U. S. G.

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PERSONAL AND SCIENTIFIC NEWS.

THE GEOGRAPHIC SOCIETY OF CHICAGO gave a reception in honor of Professor S. W. Williston on Friday evening, January fifteenth.

KARL ALFRED VON ZITTEL, the noted paleontologist, professor of geology and paleontology in the University of Munich, died on January 6th.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of December 16th Mr. C. Willard Hayes gave the presidential address; his subject was "Should there be a Federal Department of Mines?"

DR. J. MORGAN CLEMENTS, formerly of the University of Wisconsin and the U. S. Geological Survey, has opened an office as economic geologist and mining engineer in the Corn Exchange Bank building, 11 William Street, New York City.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of January 13th the following program was presented: "Work of the Strassburg seismological congress," H. F. Reid; "Experiment on the pollution of deep wells in Georgia," M. L. Fuller; "Tin ores of the York region, Alaska," Arthur J. Collier.

THE WINTER COURSE OF FREE LECTURES of the Chicago Academy of Sciences includes the following: "Flying Reptiles," Dr. Samuel W. Williston; "Our southwestern Desert," Dr. Henry C. Cowles; "The Geological Time Scale," Stuart Weller; "The Mississippi valley Lead and Zinc districts," Dr. Ulysses S. Grant.

IT IS NOT VERY OFTEN that the geologist has occasion to make predictions with regard to the occurrence of valuable minerals. His function is ottener the less glorious one of following the prospector, pass upon his reports, and to assist in the development of deposits that are already partly known. So much the more notable are the instances when he makes predictions, based on the grounds of his own science, and when these turn out to be true. Dr. W. B. Phillips, the director of the Texas University Mineral Survey, has lately had the satisfaction of seeing such a prediction verified. Last fall, while in the country to the southeast of the Chisos mountains he noted the geological resemblance of this region and the Terlingua quicksilver district. There are the same Terranes and the same associations of minerals in both places. He expressed his belief that this territory would be found to have deposits of cinnabar. His prediction has just lately been verified by prospectors, who have visited the territory and returned with reports which substantiate Dr. Phillips' prediction. J. A. U.

NEW MEXICO ACADEMY OF SCIENCES. The regular annual meeting of the New Mexico Academy of Sciences, held December 28, at Santa Fe, was well attended and interesting papers presented. The geological part of the programme included the following: Presidential address by Hon. Frank Springer on the Life of Louis Agassiz; Note on Block mountains by Dr. Charles R. Keyes; New rapid assay method for Zinc, by professor Francis C. Lincoln; Glaciation in the high plateau of Bolivia, by professor W. G. Tight; Revised Geological Column for New Mexico, by Dr. Chas. R. Keyes; Notes on some New Mexico minerals, by Dr. Rufus M. Bagg; Some Irrigation problems in New Mexico, by professor Oliver R. Smith; Geographic development of South America, by professor W. G. Tight.

The president of the Academy is Hon. Frank Springer of Las Vegas; vice-president, Dr. Charles R. Keyes, president of the New Mexico School of Mines, Socorro; Secretary, is Dr. W. G. Tight of Albuquerque, president of the University of New Mexico.

UNITED STATES GEOLOGICAL SURVEY.

During the last summer the Seward peninsula of Alaska was studied by a party under the leadership of D. C. Witherspoon, assistant topographer; with the party were F. H. Moffit, assistant geologist, and E. C. Hill, topographic field assistant. The season's work resulted in the completion of the preliminary topographic mapping of the entire area of Seward peninsula, while Mr. Moffit completed a geological reconnaissance of the region and studied in more detail the creeks in which gold has been produced.

The Deer Creek coal field of Arizona has had a preliminary examination made by M. R. Campbell. This field is in Pinal county and about eighty-five miles northeast of Tucson. The field is about ten by five miles in area as far as now known, and the coal, which is of Cretaceous age, is principally in two beds which run from 24 to 30 inches in thickness. From the incomplete examination thus far made the coal seems to be a bituminous coking coal with volatile matter running from 23 to 36 per cent. and a high ash percentage. This coal field may have economic importance because of its proximity to the great copper camps of Arizona.

The Tishomingo (Indian Territory) folio (No. 98) of the Geologic Atlas of the United States has recently been issued. It was written by Joseph A. Taff. In the area here reported on are about 437,000 acres of coal lands and over 7,000 acres of asphalt land. The asphalt deposits are particularly described in this folio.

The question of the pollution of the Androscoggin river, of Maine, by wood pulp is being investigated by Franklin C. Robinson.

The Hayden Peak (Utah) topographic quadrangle has recently been published. This, together with the adjoining Coalville quadrangle, covers the western portion of the Uinta forest reserve.

FIG. 1. OUTCROP OF CRETACEOUS CONGLOMERATE ON ASH CREEK.

FIG. 1. OUTCROP OF CRETACEOUS CONGLOMERATE ON ASH CREEK.

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CONGLOMERATE DIKES IN SOUTHERN ARIZONA.*

By MARIUS R. CAMPBELL, Washington, D. C.

PLATES IV-V.

Until within the last ten or fifteen years few examples of clastic dikes had been recognized in this country and little was known regarding their origin. Recently through the publications of Diller,† Cross,‡ Crosby,§ Ransome,|| McCallie,¶ Newsom,** and others, dikes of this character are found to be of relatively common occurrence, especially in the west, and in some cases the source of the material and the mode of its accumulation have been fairly well determined. In most cases the material is thought to have been forced up in an open or incipient fissure from some underlying bed, but in only a few cases has the existence of such a source of supply been demonstrated.

During the past summer the writer had the opportunity of examining in southern Arizona some peculiar conglomerate dikes which are composed of material that can be correlated definitely with an underlying bed, and he takes this occasion

* Published by permission of the Director of the U. S. Geological Survey.

† J. S. DILLER. "Sandstone Dikes" *Bull. Geol. Soc. Am.*, vol. i, 1890, pp. 411-442.

‡ WHITMAN CROSS. "Intrusive Sandstone Dikes in Granite," *Bull. Geol. Soc. Am.*, vol. v, 1893, pp. 225-230.

§ W. O. CROSBY. "Sandstone Dikes accompanying the Great Fault of Ute Pass, Colorado." *Essex Inst. Bull.*, vol. xxvii, 1897, pp. 113-147.

|| F. L. RANSOME. "A Peculiar Clastic Dike near Ouray, Colorado, and Its Associate Deposit of Silver Ore," *Trans. Am. Inst. Min. Eng.*, vol. xxx, 1900, pp. 227-236.

¶ S. . McCALLIE. "Sandstone Dikes near Columbus, Georgia," AMER. GEOL., vol. xxxii, 1903, pp. 199-202.

** J. F. NEWSOM. "Clastic Dikes," *Bull. Geol. Soc. Am.*, vol. xiv, 1903, pp. 227-268.

briefly to describe them so that they may be added to the list of well determined cases.

The territory in question lies about eighty miles northeast of Tucson and near the south bank of the Gila river. The exact location is in the vicinity of Saddle mountain, six miles east of Dudleyville which is situated at the junction of the San Pedro and Gila rivers.

The geologic features of the region consist of an irregular open synclinal basin of Paleozoic rocks, extending from the Upper Carboniferous limestone down to and including a large series of Middle Cambrian quartzytes. In this basin and in general lying conformably upon the beds of limestone are coal-bearing sandstones and shales from which determinative fossils have not yet been obtained, but, which provisionally have been assigned to the upper part of the Cretaceous. These beds have a thickness varying from ten or fifteen feet on the west side of the basin in the vicinity of Saddle mountain to 400 or 500 feet on the east side where they outcrop along the base of Mescal mountain. Overlying the shales and sandstones just described is a great mass of andesyte, which doubtless was poured out as surface flows in the synclinal basin. There is no sharp line of division between the igneous and sedimentary rocks, and along the contact there is more or less interbedding as though sedimentation was at times interrupted by lava flows and then again was resumed under more favorable conditions. Over most of the basin the zone of transition from sedimentary to igneous is marked by a thick bed of conglomerate, consisting of a matrix of andesitic tuff cementing well-rounded boulders of all sizes from a few inches to ten or more feet in diameter. Figure 1 shows the character of this bed as it is exposed on Ash creek directly east of Saddle mountain. At this point the bed dips to the left at an angle of about 45 degrees and the boulders are badly crushed and faulted as a result of movement in the rocks. The boulders are composed chiefly of granite and material derived from the Paleozoic limestones and quartzytes. The amount of andesitic material poured out into the basin is not known, but in its maximum development it probably has a depth of not less than 1,000 feet.

The Tertiary history of the region is complicated, consisting of great erosion intervals in which large masses of gravel were produced and then volcanic flows that conceal much of the older topography. The gravel beds are semi-indurated and they attain a thickness of several hundred feet, but they are composed of andesitic material, or of gravel derived from the erosion of the Tertiary lavas and consequently they do not in any respect resemble the underlying Cretaceous conglomerate.

The dikes were called to the attention of the writer by Mr. N. H. Mellor of Dudleyville, who has made quite an exhaustive study of the geology of the region. Two such dikes were seen, and the writer was assured that others of similar character are to be found in the region. One of the dikes cuts the andesyte in a deep part of the basin on Ash creek, about one mile above the camp of the Saddle Mountain Mining Company. This is a small dike ranging from two inches to ten or twelve inches in thickness. It cuts the andesyte at an angle of about seventy-five degrees, and the rock, for a distance of a few feet on either side shows parallel cleavage planes as if there had been considerable movement connected with the formation of the fissure. The dike is a conglomerate composed of the same material as the great conglomerate bed at the base of the andesyte, but only the smaller pebbles are present. Limestone pebbles, having a thickness of at least two inches, were seen in this dike and granite and quartzyte pebbles of a like size are also of common occurrence.

The other dike shows in a small ravine just south of Saddle mountain, and a photograph of its outcrop is reproduced in Figure 2. As may be seen in that figure, it dips at an angle of about sixty degrees and is of varying thickness, ranging from nearly a foot at the bottom of the ravine to only a few inches at the top of the slope where it branches, as shown in the upper parts of the view. As shown in the cut it is a conglomerate composed of pebbles of limestone, quartzyte and igneous rocks. One of these boulders, showing in the photograph, has a diameter of four or five inches.

The material composing both dikes is the same as that of the underlying conglomerate previously described, and since it is the only bed of this character, it is reasonably certain that the material was either forced up along lines of fracture, or flowed up in an open fissure under strong hydrostatic pressure. With the evidence at hand it is impossible to say definitely how far this material has moved upward in the fissures, but a rough estimate would put the bed of conglomerate at a depth of 200 or 300 feet in the locality south of Saddle mountain, and probably 500 feet at the dike showing on Ash creek.

REGULATION OF NOMENCLATURE IN THE WORK OF THE U. S. GEOLOGICAL SURVEY.

By G. K. GILBERT, Washington, D. C.

The growth of language is in large part unconscious and spontaneous. Spontaneous growth responds to diverse stimuli, and lacks symmetry and uniformity. The resulting irregularity is always a disadvantage, and it sometimes becomes, as in the case of the spelling of English, an enormously expensive burden. The remedy for such evils is regulation, but regulation also has its disadvantages, for it interferes with adjustment to new conditions, and thus hampers normal growth. In literary economy, as in political economy, every law is a restriction of freedom. If wisely framed its general effect is beneficent, but no law is so wise that all of its applications are free from harm. And if a law is too specific and detailed, the advantages it confers by uniformity are outweighed by the disadvantages it entails by restriction of liberty.

These general principles are applicable not only to language at large, but to technical terminology; and the problems of regulation are more keenly felt in technical fields, because there the accession of new ideas is comparatively rapid and the demand for new terms constant and imperative.

The administrative officers of the United States Geological Survey, supervising the work of a large corps and responsible for a large body of technical publication, have been so impressed by the advantages of freedom in the prosecution of research, that they have been slow to impose restriction even on systematic terminology. When, however, the publication of the geologic atlas of the United States was commenced, it became necessary to formulate a comprehensive and far-seeing plan, and in the elaboration of that plan a certain amount of uniformity in the use of terms was imperative. The rules of nomenclature and classification published in 1890, in the Tenth Annual Report of the Survey, were notably conservative, embodying the minimum of regulation consistent with the orderly progress of geologic mapping and map publication. As the areal work progressed and geologic folios were prepared, edited and published, many questions of nomenclature arose which were not covered by the regulations, and the decision of these developed a system of precedents, analogous to the common law in distinction from statutory law. Experience in the application of the rules also discovered various ways in which the rules themselves might be improved, and after a period of thirteen years it seemed best to give them a thorough revision, changing them wherever experience had found them at fault, and making them more specific by codifying some of the regulations which had been developed through the decision of practical questions. The work of revision was performed chiefly by a committee of eight geologists and paleontologists, but they solicited and received, at various stages of the work, the opinions, suggestions, and criticisms of all their colleagues, and their final draft was also modified by the Director before publication. It is printed in the Twenty-fourth Annual Report, pages 23-27.

Every published writing makes its contribution to usage in the matter of nomenclature, and thereby has a measure of influence on the choice of words by others. As the literary product of the United States Geological Survey is large, the contribution made by its members to American usage in the matter of geologic terms must be counted as important. While, therefore, the rules adopted by the Survey apply directly only to the publications of its members, they can not fail to have more or less influence on the practice of others. This gives the new rules a field of interest much wider than the corps to whose work they directly pertain, and is my justification for inviting attention, through the pages of this journal, to some of the changes they embody.

In the earlier rules rocks were grouped, for purposes of the map, into four classes: (a) Fossiliferous clastic, (b) superficial, (c) ancient crystalline, and (d) volcanic. In the new rules they are classed as (a) sedimentary, (b) igneous, and (c) metamorphic. *Sedimentary* is used in a broad sense, to include rocks formed by aqueous, organic, glacial, and eolian agencies. The word "formation," which under the earlier rules was practically restricted to structural divisions of the fossiliferous clastics, is now applied to rocks of all classes. It is the cartographic unit or individual, and is ordinarily the smallest rock body separately named and mapped. Exceptionally, and chiefly in connection with economic work, smaller bodies, called members, are represented and named.

Under the earlier rules the sedimentary formation was defined by its physical characters alone, its fossil contents being used only for purposes of correlation. Under the new rules its definition may depend largely on contained fossils.

In the classification of formations, the earlier rules specified but one category—the period—thus giving fixed taxonomic rank to only two words—"formation" and "period." The new rules substitute (in the geologic atlas) the corresponding rock term "system" for the time term "period," and give definite rank to intermediate terms. Arranged according to rank, and beginning with the lowest, their scheme of stratigraphic divisions is *member, formation, group, series, system.* Members, formations and groups are local or provincial, series are provincial or broader, systems are world-wide.

As will be seen by the subjoined table, Pleistocene, Neocene, and Eocene are abandoned as primary classific terms, and Quaternary and Tertiary are re-established. Pleistocene is given series rank, to include the deposits of the glacial period, and return is made to the Lyellian divisions of the Tertiary. The compound Jura-Trias is abandoned; Permian, Pennsylvanian, and Mississippian are recognized as series of the Carboniferous; Ordovician is accepted in place of Lower Silurian, and given rank as a system; and Saratogan, Acadian, and Georgian are adopted as series of the Cambrian. Algonkian and Archean are redefined in such way as to recognize the presence of metamorphic clastics among the dominantly igneous rocks of the Archean.

gories for classification of formations.

	In Twenty-fourth Annual Report.	
	System.	*Series.*
	Quaternary	Recent Pleistocene
	Tertiary	Pliocene Miocene Oligocene Eocene
	Cretaceous	
	Jurassic Triassic	
us	Carboniferous	Permian Pennsylvanian Mississippian
	Devonian	
	Silurian Ordovician	
ı	Cambrian	Saratogan Acadian Georgian
ın	Algonkian	
ı	Archean	

the new rules are much fuller than the old, it would be
to indicate a large number of changes of the nature
litions, but for these it seems best to refer the reader to
tual text. Being fuller, the rules are of course more re-
ve, but their restrictions are mainly such as have seemed
demanded by experience. As their points of application
numerous, care has been taken to provide adequate ma-
ry for their administration. A permanent board, called
Committee on Geologic Names, has been instituted and
ged with the scrutiny of all formation, group, and series
ies offered for publication in connection with Survey work.
this committee members of the Survey are required to sub-
the names of formations, etc., occurring in manuscripts
red for publication, and the committee, which began its
rk more than a year ago, has also considered questions in
minology submitted to the Survey by other American geol-

ogists wishing to conform their practice to that of the Survey.

One of its important functions is to guard against the duplications of formation names. Some years ago the preparation of a card list of North American formation names was begun by Mr. F. B. Weeks. After its plan had been fully developed and a considerable body of literature covered, the work was hastened by the temporary detail of a number of geologists and paleontologists, and it has been continued to the present time. So much of it as represents the literature of North America previous to January 1, 1901, has been printed in Bulletin No. 191. Yearly installments are issued in connection with the annual "Bibliography and index of North American geology, etc.," and the card list keeps the record practically complete to date. The Survey is thus enabled to inform not only its members but all interested persons whether a name newly proposed for some stratigraphic division has or has not been preoccupied by other use in North America. No attempt has been made to cover the literature relating to other continents, because intercontinental duplication can occasion no confusion, except possibly in the case of major terms used for purposes of correlation.

The present writing is not a review, but rather a notice. As I am not only a member of the Geological Survey, but have been personally connected with much of the administrative work here outlined, it has seemed fitting that I present the facts without commendation or criticism; and I have refrained also from adducing the considerations on which the determination of mooted points has been based. But there is a single factor in the Survey's point of view which it is perhaps well to state. In all the various discussions as to choice of names and the determination of principles by which to regulate such choice, the primary consideration has been the convenience of the geologic public, and no account has been taken of the personal factor. Where priority has been the criterion of selection it has been used because it affords a rule of simple application, and not because the authors of names are conceived to have "rights" in the matter. For myself, I share the view of Darwin, that the accentuation of personal credit for the giving of names is the bane of systematic terminology in biology, and believe that it should be scrupulously avoided in geology.

DALL'S CONTRIBUTIONS TO THE TERTIARY FAUNA OF FLORIDA.*

This stupendous paleontologic and stratigraphic work was begun in 1885. Five years later the first printed result appeared, and during the past thirteen years six parts have been issued with more than 1650 pages of text and sixty plates of illustrations. Adding together the names recorded in the six indexes and allowing for duplication of names, we learn that Dr. Dall has examined into and made some statement to no less than 10,400 genera, species and varieties of Tertiary or Recent animals, mainly, however, mollusca. This immense amount of research work had to be done to adjust about 3,162 species of Tertiary mollusca occuring from the base of the Oligocene to the present fauna.

In this work no special attention is given the Eocene faunas as these are being elaborated by professor G. D. Harris of Cornell University. It has been Dr. Dall's intention to exploit "the Tampa silex beds, the Chesapeake Miocene, and the rich fauna of the Caloosahatchie marls." The material accumulated so rapidly that "much of it had to be put aside in order to complete the work at all."

"If the work were to be begun now for the first time, it is probable that the number of species would be greatly increased in the gastropod groups treated of in Parts I. and II. But this sort of thing would go on forever, so great is the richness of our Tertiaries, and an attempt to include the novelties thus passed over would have prolonged indefinitely the task in hand. Enough is known to render such a course unnecessary for drawing the broad conclusions which form the most important result of these studies.

"During the progress of this work approximately eight thousand three hundred and fifty species have been discussed or compared and eight hundred and sixty new forms described. More than fifty new group-names, from sections to genera, have been proposed and more than five times as many reduced to the rank of synonyms as unnecessary

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* The full title of this work is "Contributions to the Tertiary Fauna of Florida with especial reference to the Silex-beds of Tampa and the Pliocene beds of the Caloosahatchie River." By WILLIAM HEALEY DALL. *Trans. Wagner Free Institute of Science*, Philadelphia, vol. iii. Part I, Pulmonata, Opisthobranchiata and Orthodont gastropods; August, 1890; price, $2.50. Part II, Streptodont and other gastropods concluded; Dec., 1892; price $3.00. Part III, A new classification of the Pelecypoda; March, 1895; price $0.75. Part IV, Prionodesmacea: Nucula to Julia, Teleodesmacea: Teredo to Ervilia; April, 1898; price $3.00. Part V, Teleodesmacea: Solen to Diplodonta; Dec., 1900; price $3.00 Part VI, Concluding the work; Oct. 1903; price $3.50.
Synopsis prepared by CHARLES SCHUCHERT, Washington, D. C.

or belated. The number of species known at present between the beginning of the Oligocene and the present fauna is between three and four thousand, probably less than half as many as will eventually be obtained and discriminated.

"In the course of the work it became necessary to consider the systematic arrangement of the Pelecypoda. The general subject required revision in the light of recent researches, both in anatomy and paleontology. With this view Part III. was devoted to a compilation of existing data, in which material from many sources was brought together and an approximate classification deduced."

The class Pelecypoda is here divided into the orders: I, Prionodesmacea (subdivided into 10 superfamilies and 34 families); II, Anomalodesmacea (3 superfamilies and 15 families); and III, Teleodesmacea (17 superfamilies and 46 families).

"In the earlier part of the work it was recognized that the so-called Miocene of Florida comprised two very dissimilar faunas, and to the earlier the term Old Miocene was applied in this work. Further study and material showed that this "Old Miocene" had nothing to do with the Miocene of the United States in its most typical development, as in Virginia and Maryland, but represented a group of horizons strictly analogous to those which had received from European geologists the name of Oligocene.

"These horizons contained a very rich warm-water fauna which was soon found to be more or less distinctly represented in the Tertiaries of Middle America and the West Indian Islands. This fauna then had to be examined and collections made at Bowden, Jamaica, and other important points in order that the correlation of the Antillean and continental beds might be discovered and duplication of descriptions avoided. It was found that the connection between the Atlantic and Pacific faunas ceased at about the climax of the Oligocene, and that the relations between the faunas were so intimate that the Pacific coast forms could not safely be entirely neglected. This conditon of things will account for the references to faunas not strictly Floridian, of which this work contains so many, yet which were essential to the proper understanding of both the paleontological and geological evolution of the region concerned.

"Among other things accomplished, several distinct Oligocene faunas have been worked out with fullness and their relations established; a wide extension has been given to the Pliocene deposits, long confused with those of the upper Miocene; the geological relations of the beds between the Vicksburgian and the Pleistocene have been established in their main lines more clearly than has hitherto been the case in the region studied; the species of half a dozen faunas have been revised, their nomenclature modernized, many new forms recognized, described, and figured; old confusions have been cleared up, old errors rectified, and a substantial advance in the Tertiary paleontology of our southeastern coastal plain has been secured.

"When we remember that the successive Tertiary strata on our southeastern coastal plain are composed of nearly identical materials, one stratum being often built of the débris of those immediately preceding it; that their chemical and mineralogical constituents are necessarily practically the same; that the soft nature of the rocks, even when consolidated, lends itself to erosion and to obscuration by the subtropical luxuriant vegetation,—it would seem hardly necessary to reassert the truth so often lost sight of, that geological work which does not take careful account of the paleontological data in this region is practically futile. Nearly all the errors into which geologists have been led in this part of the country, practically all the inaccurate theorizing and incidental controversy, has arisen from ignorance of or too superficial examination of the fossil contents of these rocks. The work already done is still insufficient for any final consensus of opinion. Those beds which have afforded a well-preserved fauna are doubtless fairly well understood, that there are others like them not yet known is eminently probable, and that there are numerous others in which the removal of the fossils by solution has delayed recognition of their existence and relative importance is certain. The latter, affording only casts, or, in some fortunate cases, silicious pseudomorphs of the contained fossils, can only be intelligently studied when the intervening better-preserved faunas are thoroughly known.

"Thus a rich field is open for the paleontologist, and the explorations and publications of the Wagner Institute have had exceptional importance in calling attention to the opportunities it presents. It is earnestly to be hoped that the students needed to reap the harvest will soon be forthcoming.

"The mapping out of the distribution of the different geological horizons from many isolated observations, * * * indicated that the peninsula ot Florida has experienced a tilting by which the eastern margin has been elevated between twenty and thirty feet, while the western coast has been depressed about the same amount. This tilting is supposed to have taken place since the Pliocene.* * * Mr. Wilcox finds that, off the streams falling into the Gulf of Mexico from the peninsula in the relatively shallow waters over the submerged plateau to the west, channels cut in the limestone may be traced for some distance. As these channels, too small to make any marked feature on the usual hydrographic chart, could not have been cut since the sea has covered the plateau, the inference is obvious that they were cut before the tilting of the peninsula, when the limestone was above the level of the sea.

"Dr. J. W. Spencer has propounded some very startling hypotheses, involving the elevation of some of the Antilles and Florida many thousand feet and their submergence within a comparatively recent period of geological time.

"By the researches of Professor R. T. Hill* and Mr. T. W. Vaughan much more light has been thrown on the subject.

* *Bull. Mus. Comp. Zool.*, vol. xvi, No. 15, pp. 243-288, 1895.

"I am entirely unable to accept Dr. Spencer's hypotheses; while admitting many of the facts he brings forward, I am convinced that they admit of some other explanation. We find in the Oligocene of Bowden, landshells belonging to groups peculiar to and now inhabiting the island of Jamaica, which is sufficient evidence that since the era during which the Bowden marl was deposited, the island has never been entirely submerged. With Cuba it may be different, though I can hardly bring myself to believe that the peculiar landshell fauna which is so characteristic of that island can have been evolved since the Pleistocene. However, this question is apart from those we have to consider here.

"The proximity of Cuba to Florida and the fact that the adjacent portions are composed of organic limestones, which has long been known, led to the very natural but erroneous inference that Cuba and the peninsula were formerly continuous, and that the Florida Strait had been cut between them by the erosion due to weather and streams. and subsequently by the Gulf Stream.

"There is no doubt Cuba has been subjected to great geological convulsions, but that any considerable part of the island has been submerged since the beginning of the Miocene seems extremely doubtful and requires proof not hitherto forthcoming.

"According to Mr. Vaughan's observations the great mass of the Tertiary limestones of Cuba are middle and upper Oligocene, ranging from the Chattahoochee to the Bowden or its equivalent. The Vicksburgian and the Miocene are alike absent, no positive identification of Pliocene beds has been made, and the Pleistocene reef rocks do not occur above the sea at a greater height than thirty or forty feet.

"The, on the whole, remarkable horizontality of the Floridian strata indicates a freedom from violent changes of level from the time the peninsular limestone first emerged from the sea. Landshells in the Ocala limestone show that then dry land existed. South of the Suwannee Strait, closed in late Miocene times, there is no evidence of subsequent submersion to any serious extent. Two gentle flexures run parallel with the peninsula, having the lake district between them; a tilting of, at the most, thirty feet, up at the east, down at the west, which may have been contemporaneous with the flexures; and, for the rest, very slow and slight but probably nearly continuous elevation never exceeding one hundred feet and perhaps less than half that, with dry land and fresh-water lakes constantly existing since the Ocala islands were raised above the sea; such is the geological history of the Florida peninsula. Denudation of the organic limestones by solution rather than erosion is the prominent characteristic of the changes in the surface. Soft, crumbling under the finger-nail, the rocks of the plateau, if lifted five or six thousand feet, as claimed by Dr. Spencer, would have beeen furrowed by cañons and swept bodily into the sea. Indeed, to me the proposition is inconceivable as a fact and incompatible with every geologic and paleontologic fact ot south Florida which has come to my knowledge.

"The development of the geological characteristics of the peninsula, the approximate mapping of its formations, are features of the work that has been done during the studies for this Memoir. Another feature which has aroused some comment has been the development of our knowledge of the marine strata which in Florida and its vicinity correspond to the epoch which in Europe has come to be called and recognized, after Beyrich, as the OLIGOCENE.

"Lyell and Deshayes in dividing the Tertiary into periods used the percentage of living forms as a criterion, adopting the term Eocene for beds containing three to four per cent. of species surviving to the present day,—Miocene for those containing from seventeen to twenty per cent., and Pliocene for those of which forty to fifty per cent. survive. There are several objections to this method of classification, considered as indicating contemporaneity for the strata concerned; the view of species taken by different persons is by no means uniform; the conditions in one region may be more favorable for surviving than in another region at the same time, and the method as stated takes no account of changes of climate or earth movements on a large scale, to which fluctuations in the rate of evolution of living beings must more or less directly conform. However, in practice, the omissions have been more or less effectively supplied, and the European time column having been thus worked out, the establishment of synchronism in the scale of other countries, necessarily an approximation only, will be none the less useful because to a certain extent arbitrary.

"According to De Lapparent* European geologists are now pretty much agreed in recognizing two great divisions of the Tertiary: 1, the EOGENE system, divided into *Eocene and Oligocene* series, corresponding to a state of things still very different both geographically and faunally from the present epoch, and especially including all the Nummulitic formations; 2, the NEOGENE inaugurated in Europe by a great movement of transgression, bringing in, with the flexures of the Alps, conditions resulting in organic transformations leading to the existing fauna and flora. In its turn this system is divided into the *Miocene* and *Pliocene* series.

"The Eocene series in Europe terminated by the great earth movements which uplifted the Pyrenees and Appenines and which were accompanied by a recession of the sea at many points on the shores of northern and western Europe.

"On the Gulf and southeast Atlantic coast of North America no marked stratigraphic break has been established between the Eocene and Oligocene series. As the studies of the Eocene in this country have chiefly been made in this region, it is not surprising that most American geologists have been prone to minimize the distinctions between the Eocene and Oligocene series. Nevertheless, if the invertebrate fauna is taken into account and all allowances made for the existence of a few indications of transition, the change in the fauna is so marked that physical changes elsewhere must be assumed to account for it, since no other hypothesis has even been proposed. The parallelism between the Eocene faunas of Europe and North America is so close that no ground

* *Traite de Geologie*, ed. iv., p. 1409, 1900.

appears for taking exception to their correlation, which is generally accepted. This was clearly indicated in my 'Table of North American Tertiary Horizons,' where I state of the Eocene: 'In a wide sense it includes both Eocene and Oligocene of the present table, the two not being separated by essential stratigraphic breaks in the Gulf column or by changes in the climatic relations of the fauna.'*

"In Europe the Oligocene series followed the uplifts above referred to, and the changes which resulted in the elevation of the Alps brought it to a close. Its beginnings were marked by the encroachments of the sea upon the land, forming gulfs or lagoons deeply intersecting the continental region, and even, towards the middle of the epoch, reducing the dry land of middle and western Europe to an irregular group of large islands, while Italy, Southern Russia, and North Germany were completely submerged.

"Paleontologically the consequence of these changes—which were accompanied by a uniform and mild climate even into the Arctic regions —was the great extension of brackish water deposits, lake beds, lignitiferous and leaf-bearing strata, while the purely marine sediments were largely peripheral.

"In North America, in the coastal region the series which we have referred to the Oligocene was similarly marked by wide extension of brackish water sediments about the Mississippi embayment, more or less lignitiferous, with peripheral marine sediments. On the northwest coast a large proportion of the lignite beds are probably referable to this epoch. Until recently distinctive marine Eocene was unknown north of Puget Sound. During the Harriman expedition to Alaska, however, Dr. Palache was fortunate enough to discover much distorted uplifted and broken marine sediments with a fauna which, though small and badly preserved, I was able to recognize as typically Eocene. This occurred on the Alaskan peninsula, and these rocks are certainly below the nearly horizontal unmetamorphosed sediments of the Kenai formation which contain most of the Alaskan lignite beds. The latter pass slowly and without perceptible break or unconformity into marine shallow water conglomerates and shales carrying a typical marine Miocene invertebrate fauna. These lignite and leaf beds were referred to the Miocene by Heer, but Starkie, Gardner and others have shown that they are Eogene. I have described a similar fauna and succession from the northeastern part of the Okhotsk Sea.†

"Since the condition of the true Eocene sediments indicates great physical changes here before the deposition of the Kenai beds, and since a reasonable proportion of Miocene forms occur in the plants derived

* Eighteenth Ann. Rep. *U. S. Geol. Survey*, 1896-7, part ii, p. 332, 1898. This, as well as the fact that "Eocene" in the United States Geological Survey nomenclature is the equivalent of "*Eogene*" of European geologists, seems to have been overlooked by Miss Maury in her thesis on the Oligocene (p. 89) when she states that I use the term Oligocene as coordinate with "Eocene" and "Miocene."

† *Proc. U. S. Nat. Museum*, vol. xvi, No. 946, p. 471-478, 1893. In this paper, as in other publications of the time, the term Miocene had not yet been discarded.

from them, the conclusion that this portion of the boreal lignite-bearing rocks should be regarded as Oligocene is irresistible.

"The marine Oligocene sediments of the southern coast are at first characterized by the appearance of vast numbers of foraminifera, the species in some cases identical with European forms referred to approximately the same relative place in the Tertiary column. The organic limestones characterized by the presence of myriads of *Orbitoides* reach a remarkable thickness; the mass of this limestone, which forms the substructure of the Floridan peninsula, has been drilled to a depth of more than two thousand feet without definitely reaching the subjacent Eocene. Towards the end of this sedimentation Nummulites make their appearance for the first time in our Tertiary, and the echinoid fauna is so similar to some of that in the European Oligocene as to lead various geologists to the conclusion that a continuous coast or belt of islands must have extended from the Mediterranean region to the Antilles The thickness and extent of the Vicksburg limestone, stretching from the Floridian region to Costa Rica, and its singular absence from the Antilles, so far as yet identified, taken together with the comparative thinness of the post-nummulitic Oligocene on the Gulf coast and its enormous development in the Antillean region, the north shore of South America, and the region of Middle America south of Mexico, suggest that during the period indicated there was at first a depression of the continental border coincident with elevation of Antillean lands, while during the period of the upper Oligocene these conditions were reversed, the continental sea margin being brought near to, and even, at the Ocala islands, above the surface of the sea, while a depression of Antillean lands and Middle America permitted the formation of those great bodies of marine limestones and marls for which the upper Oligocene of those regions is so remarkable. As in Europe so in America, lake-beds were formed away from the seacoast, where the bones of Oligocene vertebrates were entombed to serve in the future as convincing evidence of contemporaneous evolution. Again, as in Europe, those changes which elevated the Alps terminated the processes assigned to Oligocene time; so in America the Middle American highlands, the larger Antillean islands, and the peninsular island of Florida were uplifted, the two Americas united, and vast physical changes consummated. Coincidently at the north the boreal coasts were gently depressed and the waters of the Miocene sea extended over the ruins of the Oligocene forests.

"As indicated by the changes in the fauna, the physical changes attending the close of the Oligocene were at first slow, allowing a certain element of transition to appear in the Oak Grove or uppermost Oligocene fauna. At the last they appear to have, been sudden, at least the change in the fauna on the Gulf coast was absolute and complete. The change was not only in the species and prevalent genera of the fauna, but a change from a subtropical to a cool temperate association of animals. Previously, since the beginning of the Eocene, on the Gulf coast the assemblage of genera in the successive faunas uniformly indicates a warm or subtropical temperature of water, and the sediments uniformly show, from the Jacksonian upward, a yellowish tinge due to oxidation. In the Oak Grove sands come the first indications of a change towards the gray of the Miocene marls. With the incursion of the colder water the change becomes complete. Not only do northern animals compose the fauna, but the southern ones are driven out, some of them surviving in the Antilles to return later. Some change along the northern coast permitted an inshore cold current to penetrate the Gulf, depositing on the floor of the shallow Suwannee Strait, separating the island of Florida from the continental shore, a thin series of Miocene sediments, which were also carried as far south as Lake Worth on the east coast of Florida and Tampa on the west coast, as shown by artesian borings.

"The movement in elevation which ushered in the Miocene continued, probably, during its entire term. It amounted in Costa Rica, according to Gabb, to several thousand feet, and permanently united the two continents.

"I concur with Hill in the belief that, whatever changes of level may have taken place since, no discontinuity of the link between North and South America from the Miocene to the present time is probable, and certainly none amounting to a free communication between the two oceans.

"The Miocene of the Gulf coast is essentially the older Miocene of Maryland and Virginia. No trace of it appears anywhere in the Antilles or on the Gulf coast west of the Mississippi embayment. The Miocene fauna of the coast of Texas, revealed by the Galveston artesian borings, is of a different stamp, more nearly allied to that of the Pacific coast. It is probable that the wide stretch of the Mississippi water pouring into the Gulf served as a barrier to the west-ward migration of species of marine invertebrates.

"As the elevation culminated, leading to the termination of the Miocene epoch, Florida became united to the continent, the Suwannee Strait was obliterated, and the influx of cold water into the Gulf ceased. Gradually the temperature rose and the exiled subtropical species began to return. The cold current must have been diverted off shore or else-where, for a migration northward, during the latter part of the Miocene, of many species and genera belonging in warmer water succeeded in reaching as far as North Carolina along the coast and some of them even as far as southern Virginia. This is quite a marked element in the Duplin fauna. Some of the northern invaders kept their foothold in the Gulf, became acclimated to the warmer temperature, and survived. It is always easier for a cold-water invertebrate to survive in water warmer than it is accustomed to than for one belonging in warm waters to persist when there is a change to a lower temperature. Brooks' experiments in Chesapeake Bay showed that a fall of two degrees Fahrenheit in the temperature of the water killed all the swimming larvæ of *Ostrea virginica,* but a rise of twice as many degrees would probably only have hastened their development.

"After the culmination of the upward movement terminating the Miocene, a slight depression of the continental border and a change in the fauna indicating a still warmer sea temperature inaugurated the Pliocene. During this period a continuance of immigration of subtropical forms, Miocene exiles and newcomers, is notable. These pushed their way northward, one species, at least, reaching Martha's Vineyard. The records of this extension were partly obliterated by the ice-sheet of the Glacial period and, even as far south as the Carolinas, are very fragmentary. The end of the Pliocene is the beginning of the Glacial epoch. The Pleistocene of Florida shows a change for the cooler and an elimination of the most purely tropical forms from the fauna, but nothing like the clean sweep at the beginning of the Miocene. The latter is the sharpest and most emphatic faunal change since the Cretaceous on our coasts. With the exception of a few widely distributed and uncharacteristic species the entire Molluscan fauna of the north shore of the Gulf was swept away and replaced by a more meagre fauna of a different type. In the face of this revolution no proposition to extend the limits of the Miocene farther down the column seems to me defensible.

"The above summary of the changes in the period between the Vicksburg and the Glacial epoch was sketched in all its main outlines in Bulletin 84 of the United States Geological Survey in 1891, and amplified in the introductory remarks to my 'Table of Tertiary Horizons' in 1895. Subsequent study has only confirmed the views drawn from the earlier work, and, as a whole, the establishment of this general view may be regarded as the most important result of this study of the Tertiary faunas of Florida. A thorough knowledge of the present faunas of the coast is almost essential to enable one to fully recognize the weight of the evidence, but I am convinced that in its main features the above sketch will stand the test of time, even though some amelioration may be expected in minor details.

"In some recent papers on the Oligocene and Eocene it has been suggested that the presence or absence of identical species in the Tertiary beds on either side of the Atlantic is an important factor in deciding the correlation of geological horizons. While this is partially true of older geological horizons, after the Mesozoic epoch the faunal characteristics of the shallow water Mollusca of different regions became rapidly distinctive. Even in the Eocene but two or three species can be claimed as identical on both shores of the Atlantic, and in later periods it would be most unreasonable to demand of subtropical marine invertebrate faunas in widely separated regions that they shall offer a series of identical species on pain of being refused correlation. We cannot ask that they shall do more than present equivalent stages of evolution in relation to preceding and subsequent faunas, or that a no greater number of identical species shall be required than are found in the contemporaneous faunas of the present day in similar cases. This is undoubtedly true of the faunas treated of in this Memoir."

EXPLANATION OF TABLE I.

"This table contains in the left hand column the names of the formations, preceded by a capital letter in descending order. There are nineteen formations mentioned and the first nineteen columns to the right, surmounted by a capital letter, represent the same formations vertically as do the horizontal lines across the table which follow the name of the formation. The figures entered in these columns indicate the number of species found common to the formation and to the other formation by which in the table it is vertically intersected. Where the vertical and horizontal columns of a single formation intersect the figures indicate the total number of species known from that formation. Thus in horizontal column F (Duplin Miocene), at the intersection of vertical column J, we find the number 18, which signifies that there are eighteen Duplin species also found in the Chipola (J) Oligocene. Column S is merely approximate, the required data to make it complete being inaccessible at present. Where no common species are known the vacancy in the intersection indicates the fact, but it must not be inferred that some may not eventually be found common to the two formations. In the column headed 'Recent' the number of species now known to survive in each horizon is entered. The next column shows the number of species now known only from that formation, numbers which future researches must inevitably add to. The next two columns give the Recent and Peculiar species in percentages of the total fauna of the formation to the nearest integer. In Bulletin 84 of the United States Geological Survey (pp. 25-31) I have discussed the question of the number of shell-bearing species of Mollusks which is normal to any one limited region. An actual count of the species found in less than one hundred fathoms on the coast of the United States between Cape Hatteras, North Carolina, and the mouth of the Savannah River affords the number of five hundred species. But in any one limited locality, as a sand beach, a rocky shore, an estuary or a lagoon, no one could find all these species. Certain kinds of terrain are more favorable to shells than others; an oyster-reef or a sand beach will always have less population than a shore of mixed mud and gravel. So I have in the column headed 'Normal Fauna' given the best estimate that I could of the number of species which might be expected to occur in the locality where collections had been made to illustrate the particular formation referred to. The last column of the Table, headed 'Fossil faunas per cent.,' shows the percentage which the forms actually found bear to the numbers theoretically probable. If the reasoning is correct, we can expect to find few if any more species than have already been collected in at least five out of the twelve formatinns so indicated, while of the Pleistocene of North Creek only about one-third of the possible species has been obtained. In a general way I believe these figures to be approximately true.

"In the vast number of species which have been considered during the construction of this table it is improbable that the figures in every case should be mathematically exact, but it is probable that the errors if corrected would not affect the general conclusions drawn from the table as it stands. In several cases if the numbers were increased it is unlikely that the percentages would be materially affected.

"The names given in the table will be familiar to the reader, but it seems worth while to specify that under G the name Chesapeake applies

TABLE I.—STATISTICS OF THE FOSSIL MOLLUSK-FAUNAS DISCUSSED IN CONTRIBUTIONS TO THE TERTIARY FAUNA OF FLORIDA.

		S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Recent	Peculiar	Total	Recent per cent.	Peculiar per cent.	Normal fauna	Fossil fauna per cent.
P.-Pl.	A, North Creek....	...	...	...	...	...	8	...	...	6	4	1	13	11	26	2	13	28	24	71	67	3	71	94	4	230	31
Pliocene.	B, Croatan.........	...	...	...	...	...	5	...	...	...	4	...	5	9	60	2	31	63	96	(71)	80	4	96	83	4	105	91
	C, Waccamaw......	...	...	...	...	...	5	...	...	...	4	1	5	23	62	2	71	180	63	(116)	125	15	180	70	8	230	78
	D, Caloosa.........	1	1	4	1	...	11	...	2	13	13	8	5	32	94	2	639	71	31	13	309	256	639	48	40	650	98
Miocene.	E, Pascagoula......	...	...	...	...	...	...	...	...	...	...	...	...	...	1	14	2	2	2	2	2	...	14	...	...	...	....
	F, Duplin..........	3	2	3	2	2	7	...	1	3	18	7	8	53	331	1	94	62	60	28	60	104	331	18	31	350	94
	G, Chesapeake......	...	...	1	1	1	2	...	...	3	5	3	2	135	53	0	32	23	9	11	13	43	135	9	32	136	100
	H, Shiloh..........	...	...	2	...	...	6	...	...	1	5	5	100	2	8	2	5	5	5	13	13	40	100	13	40	...	....
Oligocene.	I, Oak Grove.......	...	2	4	1	1	19	...	4	15	81	239	5	3	16	...	8	1	...	1	10	132	239	4	55	230	100
	J, Chipola..........	2	5	10	4	11	39	1	3	16	333	81	5	5	18	...	19	4	4	4	35	175	333	10	53	483	69
	K, Bowden.........	1	...	4	...	6	10	...	6	435	16	15	1	3	3	...	13	(6)	...	6	53	287	435	12	66	550	79
	L, Orbitolite.......	1	2	9	4	...	17	14	58	6	3	4	...	...	1	...	2	...	...	......	2	10	94	35	...	...	....
	M, Jacksonboro'....	2	2	2	...	4	1	44	14	...	1	...	...	...	...	...	...	...	...	......	...	10	44	...	...	...	....
	N, Tampa silex.....	3	2	9	11	9	193	1	17	10	39	19	6	2	7	0	11	5	5	8	15	94	193	8	50	230	84
	O, White Beach....	...	...	1	...	39	9	4	...	6	11	1	...	1	2	...	...	...	...	......	4	2	39	...	...	...	....
	P, Ocala limestone.	2	2	15	59	...	11	...	4	...	4	1	...	1	2	...	1	...	...	......	1	26	59	2	42	...	....
	Q, Vicksburgian....	3	10	122	15	1	9	2	3	4	10	4	2	1	3	1	4	...	...	......	2	102	122	2	84	230	53
Eocene.	R, Jacksonian......	1	74	10	2	...	2	...	...	...	5	2	...	2	2	...	1	...	...	......	2	67	74	3	90	230	32
	S, Earlier Eocene..	1	...	3	2	...	3	...	...	...	2	...	...	2	3	...	1	...	...	......	...	...	...	...	...	...	....

merely to the Floridian Miocene and does not include that of the more northern States. Under Pascagoula our collections include four species. Professor Smith and Mr. Aldrich announce the presence in the clay of ten more, and these have been added, though I have not seen them.

"For the Shiloh list I am mainly dependent on Professor Whitfield's monograph with some additions from my own observations. For the Vicksburg and Jackson lists I have similarly used Conrad's Checklists and included some, but not all of the late additions to these faunas.

"In the cases of the Croatan and Waccamaw beds, the figures under Column A are taken from the Pleistocene of the Carolinas and not from that of North Creek, Florida. To emphasize this distinction the figures are enclosed in parentheses. The total number of species considered in these statistics is about three thousand one hundred and sixty-two.

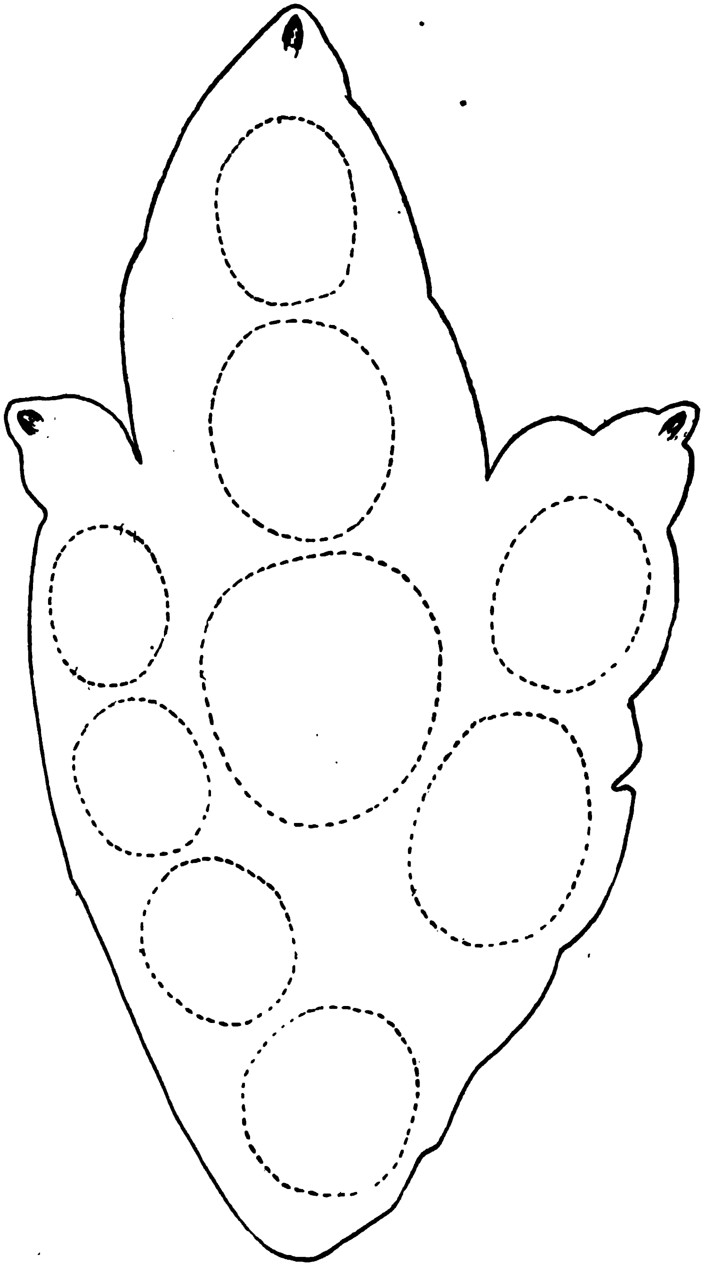
"Several of the localities have been very imperfectly explored, such as Pascagoula, the Orbitolite bed, Jacksonboro', White Beach, and the Ocala limestone; but a fair number being known, it is probable that the percentages derived from it are not far wrong. I should mention here one factor which makes for usefulness in the figures of the table. Nearly all the collections were made by one man, faithful and devoted to his work, and whose instructions were to be as thorough as possible and take all the time needed. Under these circumstances it is believed that the results are more comparable than those depending on a number of different collectors varying in energy, persistence, and experience."

A NEW FOOT-PRINT FROM THE CONNECTICUT VALLEY.

By Joseph A. Cushman, Boston, Mass.

PLATE VI.

Among the immense number of foot-prints that have been obtained from the Triassic of the Connecticut valley are very few which show distinctly webbed feet. Even if slight impressions such as the web would make were left on the mud their trace would only be seen if the resulting rock were split at the identical surface on which the animal stepped. Below this the traces would be lost and only the features preserved which were more strongly impressed. Above it the filled in layers would show still less of it. On the true surface there is in many cases a difference in color. This is probably due to the results of standing water depositing very fine mud particles before the return of the succeeding tide, or to organic matter in the water deposited at the drying up of the water.



OTOUPHEPUS MAGNIFICUS SP. NOV.

In the specimen in hand the outline of the web of the foot is, as it were, silhouetted against the somewhat lighter reddish-brown of the matrix. The line is as clear cut as though outlined with a sharp pencil. Even the notches of the sides are left distinctly showing. On page 29 of his Ichnology of Massachusetts (1858), Edward Hitchcock gives the following statement concerning tracks showing webbed feet..........

"When a web made an impression deep enough to be manifest, it is certainly an important fact, and characterizes certain animals: but I have been surprised to find how seldom distinct evidence of such an appendage appears in the fossil tracks. Yet, on examining the tracks of such animals as the goose and the duck, I find that it is only in a favorable state of the mud that any distinct trace of the web is left. We have at length found some fossil specimens with webbed feet, as the Otozoum and the Uphepus [Hyphepus].

"I have still some doubt in respect to the former: but if there be no mistake, the web extended even beyond the pellets of the toes: while in the Uphepus [Hyphepus] it probably reached to the extremity of the claws on the lateral toes, but not on the middle toe."

The specimen in hand can belong to neither of these two genera as it is distinctly tridactylous while they are both tetradactylous. The following genus is proposed for it:

Otouphepus, Gen. Nov.

(Derivation, 'Ωτος, a giant: Ύφή, a web: and πούς, a foot).

Otouphepus magnificus sp. nov.

Foot-print tridactylous, digits decidedly pachydactylous, connected by a web, incised between the digits. Impressions of the joints of the digits very indistinctly shown. Digits terminated by fairly sharp claws, the expansions however extending beyond as the foot is placed flat upon its under surface. Total length 6.5 inches, length of outer toe 4.5 in., inner toe 3.2 in., middle toe 4.5 in. From heel to tip of outer toe 4.5 in., to tip of inner toe 5 in., between tips of lateral toes 3.5 in., between inner and middle toes 3 in., between middle and outer toes 2.4 in., middle toe extends 2.2 in. beyond the lateral toes.

Type in the Boston Society of Natural History no. 12857. Specimen from Gill, Massachusetts. Triassic.

As the foot is placed flat, the web on the inner margin is spread out and the scallops distinctly seen. They are very similar to certain of the reptiles of the present time in this respect.

Although such a footprint cannot be placed in any of the present genera as they are defined by Hitchcock, it is very probable that it represents an animal of the type of *Eubrontes dananus* E. Hitch. (*Brontozoum sillimanium* E. Hitch.). However, in perfect specimens of that species in the same sort of matrix where a distinct outline is shown, there are no such traces of a web. There are slight expansions, but they are of a different nature. The measurements and number of joints are very similar, but so they are in *Pleisiornis mirabilis* of Hitchcock which is nearer *E. dananus* than the present form under discussion. The joints of the phalanges, the turning aside of the claws, and the general skeletal shape would put the animal which made the present track in group II. of Hitchcock, p. 63—although they were doubtless Dinosaurs and not "thick-toed birds," as he terms them.

Boston Society of Natural History, November, 1903.

GEOGRAPHY IN THE UNITED STATES.*

By W. M. Davis, Cambridge, Mass.

For twenty years past our section has acknowledged in its name an equal rank for Geology and Geography, but not one of the vice-presidential addresses during that period, or indeed since the foundation of the Association over fifty years ago, has been concerned with the subject second named. Unless we cross off geography from the list of our responsibilities, it should certainly receive at least occasional attention; let me therefore depart from all precedents, and, even though geologists may form the majority in this gathering, consider the standing of geography among the sciences of the United States: how it has reached the place it now occupies, and what the prospects are for its further advance.

One measure of the place that geography occupies in this country may be made by considering the share that geographical problems have had in the proceedings of our Association: here follow, therefore, the results of a brief examination of our fifty volumes of record. In the early years of

* Address of W. M. Davis, Vice-President and Chairman of Section E for 1903, American Association for the Advancement of Science, St. Louis, Mo., Dec., 1903.

the Association there was no fixed division into sections. The meetings were sometimes so small that papers from various sciences were presented in general session. At least once in the early years, the work of our predecessors was recorded under the general heading, "Natural History, etc." As early as in 1851 there was a section of geology and physical geography, and another of ethnology and geography, but that classification did not endure. Once only, in 1853. did geography stand by itself as a sectional heading, but at many meetings, physics of the globe and meterology had places to themselves. Through the '60's and '70's geography was sometimes coupled with geology, but the latter more often stood alone or with palentology, and it was not until the Montreal meeting of 1882 that Section E was definitely organized with the title that it now bears.

In those years when physics of the globe and meterology were given sectional rank, problems concerning the ocean and the atmosphere received a good share of attention. It is curious to note, in contrast to this, how little consideration has been given to the exploration and description of the lands; that is, to the geography of the lands, in this Association for the Advancement of Science, either before or after the establishment of the double name for our section. The exploration of foreign lands, for many years a prominent subject in the meetings of the British Association where geography has had a section to itself since 1869, has attracted hardly any notice in our gatherings; perhaps because we have been busy exploring our own domain. At the first meeting, 1848, a summary of then recent explorations, prepared by Alexander, is the only paper of its kind. Other papers treating of the geography of foreign lands are so few in number that most of them may be noted here; in 1850, Squier gave an evening address on the Volcanoes of Central America; in 1858 and 1860, Hayes and Wheildon discussed Arctic Exploration; Orton described the Valley of the Amazon in 1869; in 1884 and 1898, two English visitors had papers on different parts of Asia; in 1891 and 1898, Crawford described features of Nicaragua, and in 1894 and 1895, Hubbard read papers on China, Corea, and Japan. Even geological essays on foreign regions have been few; Dana, Branner, Hill, Spencer, Heilprin and Hitchcock being the chief contributors.

Inattention to foreign exploration is, however, not to be fully explained by devotion to the geography of our own country, so far as the latter is measured by the pages devoted to it in our proceedings. The first meeting started well enough, with accounts of the terraces of lake Superior by Agassiz, of the physical geography of northern Mississippi by Bolton, and of the topography of Pennsylvania and Ohio by Roberts. Again, in 1851, when physical geography was named with geology, the first subject had two essays, the distribution of animals in California, and the climate, flora, and fauna of northern Ohio; and geography, joined in the same year with ethnology had three rather scattering titles: a deep-sea bank near the Gulf Stream, measurement of hights by the barometer, and a geographical department in the Library of Congress; but this beginning had no worthy sequel. The many expeditions across our western territory contributed little geographic matter to our records; in 1856, Blake described the orography of the western United States, and Emory the boundary of the United States and Mexico; and the latter added in 1857 an account of the western mountain systems of North America. From that time onward there has been very little primarily of a geographical nature concerning the United States. Even the modern discussions of glacial geology in the last twenty years, profitable as they have been to the physical geographers of glaciated regions, have in very few if any cases been presented as contributions to geography. The new phase of the physiography of the lands is scantily represented; there have been hardly more than accounts of Mexico by Hill, of California by Perrin Smith, of North Carolina by Cobb; it is to be noted, moreover, that these three authors are primarily geologists, not geographers. This meagre showing leads one to suspect that our proceedings do not give a fair measure of geographical activity in North America.

There has been in reality a great deal of work of a geographical nature done by our people, but the proceedings of the Assocation do not seem to have commended themselves as a place to put the work on record. Our geological surveys, state and national, have contributed numerous geographic chapters and reports of prime value; our Weather Bureau is in many respects the leading institution of its kind; our Coast

Survey sets a high standard for triangulation, coast maps, and tide and current studies; we have held a prominent place in Arctic exploration, and have taken some part in exploration elsewhere. But in spite of all this accomplishment, we have not made great contributions to the full-fledged science of geography. There are, for example, few steps toward scientific geography of greater value than good maps, but for the geographer to stop with the production of good maps is as if the botanist stopped with the collection of dried plants. The survey reports of our various States and Territories contain a great fund of geographical matter, and some of the members of these surveys have carried the physical geography of the lands so far forward as to develop it into a new science, to which a name, geomorphy or geomorphogeny, has been given; yet geography has not flourished among us as a maturely developed subject. The survey reports have not, as a rule, been prepared by persons whose training and interests were primarily geographical, and very few of the geomorphogenists have carried their new science forward into a geographical relation; they have usually stopped with the physical aspects of the subject, and left the organic aspects with scanty consideration. It is as if there had been some impediments in the way of the full development of geography as a maturely organized science. There are in fact three serious impediments.

During all these years, geography has suffered greatly from being traditionally a school subject in its educational relations; the subject as a whole has been almost everywhere omitted from the later years of college and university training, although certain of its component parts have received some attention in college years. Again, geography as a whole leads to no professional career outside of school-teaching; it is, perhaps, chiefly on that account that our colleges and universities can give little time to it. Finally, there is not today in this country an organized body of mature geographical experts at all comparable in rank to the bodies of physicists or of zoologists which are organized into effective working societies; in the absence of such an organization geography suffers greatly for the lack of that aid which comes from mutual encouragement among its workers. How can we remove these impediments of low educational rank, no professional career, and no professional organization?

Geography will find a place in our colleges and universities very soon after it is shown to be a subject as worthy of such a place as are the subjects whose position is already assured. Physical geography is today slowly winning a more respected place than it has ever had among the subjects on which examinations are set for admission to college. Commercial or economic geography is, I believe, destined to attract increasing attention from mature teachers and nearly mature students. The general geography of various parts of the world must receive more and more consideration in our colleges during the century that opens with the outgrowth of our home country; and just so soon as mature teachers of mature geography can make their lectures of value to the young men of to-day, who are to be the leaders of enterprise tomorrow, place will be found for geographical courses in our higher institutions of learning. Progress in this respect is visible, though not rapid. In order to hasten progress, increased attention might well be given to so-called practical courses in geography, as well as to courses of a generally descriptive nature. The impediment of low educational rank is not permanent; it need not discourage us, for it is destined to disappear.

The study of geography is not likely soon to lead to a large, independent career, but it may be made useful in many careers, as has just been indicated. It will, however, be made particularly serviceable to a class of men that is now of small, but of increasing numbers, namely, those who travel about the world, seeking fortune, entertainment or novelty. With the present rapid increase of wealth among us, this class is destined to grow, and while it may never be large, it may soon be important, and its members need careful cultivation; and at the same time the teachers of this class and of other classes with whom geography becomes important, will win a respected career for themselves. The impediment arising from the lack of a large professional career will therefore have no great importance when the many relations of mature geography to other subjects are recognized.

The third impediment to the maturing of geography is the most easily overcome, even if at present the most serious, for its removal depends only on the action of geographers themselves, and not on the action of higher bodies, such as executive offices, trustees, and so on, or on the action of lower bodies, such as students. The absence of a society of mature geographical experts is the fault of the experts themselves. No greater assistance to the development of mature scientific geography lies within our reach than the establishment of a geographical society which shall take rank with the Geological Society of America, for example, as a society of experts, in which membership shall be open only to those whose interests are primarily geographical and whose capacity has been proved by published original work in a distinctly geographical field. In order to determine whether such a society can now be organized, I propose to consider the classes of persons in the community from which the members of the society could be recruited.

There are at least four classes of geographical associates, as they may be called, from which mature geographical experts might be drawn. First and in largest number is the class consisting of the teachers of geography in our schools. It is true that our school teachers, as a rule, devote themselves to immature geography; that is, to only so much of the whole content of the subject as can be understood by minors, indeed by children. But, on the other hand, one who is acquainted with recent educational progress cannot fail to recognize the notable advance made in the last ten years alone in the preparation for and in the performance of geographical teaching. There are in the secondary schools today a number of teachers who are competent to make original, mature geographical exploration of their home country, and some of them have actually traveled east and west with the object of making geographical studies. There are several teachers' geography clubs, and the leading members of these clubs are thoughtful workers. I am sure that a significant number of acceptable members of an expert geographical society would be found in this class.

The second class of geographical associates includes the observers of the national and state weather services, who have chiefly to do with that important branch of geography comprehended under climatology; these observers are gathering a great crop of facts, not always very accurately determined or very widely applied as far as the observers in the state services are concerned; yet from among the thousands of persons thus employed there will now and then come forth the original worker whose contribution will fully entitle him to expert rank; when his published studies are seen to be of a thoroughly geographical character and of a mature grade, they would warrant his admission to a society of geographical experts.

Third comes the class made up from the members of various governmental bureaus, state and national, whose work is of a more or less geographical character; for example, topographers and hydrographers; geologists and biologists; ethnologists and statisticians: this class being as a whole of much higher scientific standing than the two classes already mentioned. It may happen that many persons thus classified have a first interest in the strictly geographical side of their studies, although faithful work in the organization to which they belong associates them with other sciences. I should expect the greatest part of the membership in a society of geographical experts to be drawn from this class.

It may be noted that the absence of a body of mature geographers, as well organized and as scientifically productive as are the workers in various other sciences, is explained by some as an inherent characteristic of geography, necessitated by the great diversity of its methods and its interests. The diversity is already an embarrassment, it is claimed, even in school years; and it afterwards compels the separation of the branches of this highly composite subject, at best but loosely coherent, into a number of specialties, each of which is so much more closely allied to other sciences than to the other branches of geography that those workers whose union would constitute a body of mature geographical experts are found scattered among other unions, geological, botanical, zoological, ethnological, economical and historical. The claim that the disunion of geographical experts is necessary does not seem to me well founded. May we not indeed prove that there is no such disunion by pointing to the fourth class of geographical associates, concerning whom my silence thus far may perhaps have awakened your curiosity, namely, the members of our various geographical societies?

There are at the present time between five and seven thousand such persons in the United States, but in the absence of any standard of geographical knowledge from the requirements for membership, these societies cannot, I regret to say, be taken as evidence that there is a common bond by which experts in all branches of geography are held together. None of our geographical societies are composed solely of experts, and none of them are held together by purely geographical bonds. While we must not overlook the excellent work that our geographical societies have done, neither must we overlook the fact that in making no sufficient attempt to require geographical expertness as a condition for membership, there is a very important work that the societies have left undone. They have truly enough cultivated a general interest in subjects of a more or less geographical nature, but they have failed to develop geography as a mature science. Indeed it may be cogently maintained that the absence of any standard of geographical knowledge as a condition for society membership has worked as seriously against the development of mature scientific geography as has the general abandonment of geographical teaching to the secondary schools. Large membership seems to be essential to the maintenance of good libraries in handsome society buildings, and it is certainly helpful in the collection of funds with which journals may be published and with which exploring expeditions may be equipped and sent out. I should regret to see the membership in a single existing geographical society decreased, but I regret also that there is no geographical society of the same rank as the American Mathematical Society, the American Physical Society, or many others in which number of members is secondary to expert quality of members. Large numbers of untrained persons are not found necessary to the maintenance of vigorous societies in which these other sciences are productively cultivated, and it is therefore reasonable to believe that large numbers would not be essential to the formation of a geographical society of high standing. Indeed, it can hardly be doubted that the acceptance of a low standard for membership in our geographical societies has had much to do with the prevailing indifference regarding the development of a high standard for the qualification of geographical experts.

Not only may any respectable person obtain membership in any of our geographical societies, however ignorant he may be of geography, but various kinds of societies are ranked as geographical, even though their object may be geographical in a very small degree. This is indicated by a list of geographical societies recently published, in which is included a small Travellers Club lately organized in one corner of our country. The object of this club is simply "the encouragement of intelligent travel and exploration." Interest in rather than accomplishment of exploration and travel suffice to recommend a candidate, otherwise qualified, for membership. The object of travel is nowhere stated to be geographical. As a matter of fact, travel for the sake of art, archæology, language, history, astronomy, geology and botany, for discovery, or even only for sport and adventure, as well as for strictly geographical objects, is encouraged by this young organization, which is really nothing more than its name claims it to be: a travellers club. The same list of geographical societies includes several clubs of excursionists, outing-takers, or mountain climbers, among whom, as a matter of fact, geography attracts hardly more interest than botany. These societies are doing an excellent work in taking their members outdoors, sometimes on walks near home, sometimes farther away to a hotel in the country, sometimes to a camp among the mountains. The chief result of such outings is an increased enjoyment and appreciation of the landscape, of natural scenery, and of everything that enters into it; but this excellent result is by no means exclusively, perhaps not even largely, geographic in its quality.

One might question whether geographic rank was really accorded to these clubs by general assent, if their recognition in the group of geographical societies were expressed only by an individual opinion in the list referred to; but this is not the case. In preparation for the meeting of the International Geographical Congress, to be held in this country next summer, delegates to the committee of management have been invited from the Appalachian Mountain Club, in one corner of the country, and from the Mazamas in another. The delegates appointed by these clubs, are, as might have been expected, men competent to act with others in organizing the Congress for us, but the same result would have been attained if delegates had been asked from the various geological, botanical, zoological, and historical societies, for all these societies contain among their members persons of a certain amount of geographical knowledge and of a sufficient executive ability. The same would be true had delegates been invited from the Boone and Crocket Club, a choice organization of sportsmen, for all such clubs have men of undoubted ability in the way of organization among their members, and are largely concerned with matters of geographical location and distribution in their activities. Nevertheless neither the sporting nor the outing clubs are essentially or characteristically geographical in their objects. Do not, however, understand me to object to the acceptance of delegates from the above-named clubs as members of the committee on management of the International Geographical Congress. I approve of the plan heartily; for in the absence of geographical societies in many parts of our country there was no other plan so appropriate. The matter is mentioned here only to show the straits to which geographers are reduced in attempting to give a national welcome to an international geographical congress; the difficulty, so far as it is a difficulty, arises from the absence among us of a body of mature geographical experts, united in an advanced acquaintance with some large part of a well-defined science. This condition of things seems to me unsatisfactory. The absence of a strong society of geographical experts indicates an insufficient attention to scientific geography, and I therefore now turn to consider the direction in which serious efforts may be most profitably made toward a better condition of things. Let it be understood, however, that no quick-acting remedy is possible, for the reason that many of those concerned with the problem —namely, the advance of scientific geography—do not seem to recognize that the existing state of things needs a remedy. It is therefore only as a change of heart—a scientific change of the geographic heart—makes itself felt that much can be accomplished toward the development of scientific geography, and such a change is notoriously of slow accomplishment. Progress is apparent, however, and from progress we may gather encouragement. In what direction, then, shall our further efforts be turned?

Let me urge in the first place that close scrutiny should be given to things that are popularly called geographical, with the object of determining the essential content of geographical science and of excluding from our responsibility everything that is not essentially geographic. Only in this way can we clear the ground for the cultivation of really geographical problems in geographical education and in geographical societies. This scrutiny should be exercised all along the line: in the preparation of text-books, in the training of teachers, in the study of experts, and in the conduct of any geographical society that attempts to take a really scientific position. The essential content of geographical science is so large that the successful cultivation of the whole of it demands all the energies of many experts. Those who are earnestly engaged in cultivating geography proper should treat non-geographic problems in the same way that a careful farmer would treat blades of grass in his cornfield: he would treat them as weeds and cut them out, for, however useful grass is in its own place, its growth in the cornfield will weaken the growth of the corn. So in the field of geographical study, there is no room for both geography and history; geography and geology; geography and astronomy. Geography will never gain the disciplinary quality that is so profitable in other subjects until it is as jealously guarded from the intrusion of irrevelant items as is physics or geometry or Latin. Indeed the analogy of the blades of grass in the cornfield is hardly strong enough. It is well known that Ritter, the originator of the causal notion in geography, and therefore the greatest benefactor of geography in the nineteenth century, was so hospitable in his treatment of history that his pupils grew up in large number to be historians and his own subject was in a way lost sight of by many of his students who became professors of geography, so-called, in the German universities, until Peschel revolted and turned attention again to the essential features of geography proper.

Close scrutiny of what is commonly called geography will certainly be beneficial in bringing forward the essence of the subject and in relegating irrevelant topics to the background; but it is not to be expected that any precise agreement will soon be reached as to what constitutes geography, strictly interpreted. Opinions on the subject, gathered from different parts of the country, even if gathered from persons entitled to speak with what is called "authority," would probably differ as widely as did the nomenclatures of the leading physiographic divisions of North America as proposed in a symposium a few years ago; but if careful consideration and free discussion are given to the subject, unity of opinion will in due time be approached as closely as is desirable.

As a contribution toward this collection of opinions, let me state my own view: the essential in geography is a relation between the elements of terrestrial environment and the items of organic response; this being only a modernized extension of Ritter's view. Everything that involves such a relationship is to that extent geographic. Anything in which such a relationship is wanting is to that extent not geographic. The location of a manufacturing village at a point where a stream affords water-power is an example of the kind of relation that is meant, and if this example is accepted, then the reasonable principle of continuity will guide us to include under geography every other example in which the way that organic forms have of doing things is conditioned by their inorganic environment. The organic part of geography must not be limited to man, because the time is now past when man is studied altogether apart from the other forms of life on the earth. The colonies of ants on our western deserts, with their burrows, their hills, their roads and their threshing floors, exhibit responses to elements of environment found in soil and climate as clearly as a manufacturing village exhibits a response to water power. The different coloration of the dorsal and ventral parts of fish is a response to the external illumination of our non-luminous earth. The word *arrive* is a persistent memorial of the importance long ago attached to a successful crossing of the shore line that separates the sea and land. It is not significant whether the relation and the elements that enter into it are of easy or difficult understanding, nor whether they are what we call important or unimportant, familiar or unfamiliar. The essential quality of geography is that it involves relations of things organic and inorganic; and the entire content of geography would include all such relations. A large library would be required to hold a full statement of so broad a subject, but elementary text-books of geography may be made by selecting from the whole content such relations as are elementary, and serviceable handbooks may be made by selecting such relations as seem important from their frequency or their significance. The essential throughout would, however, still be a relation of earth and life, practically as Ritter phrased it when he took the important step of introducing the causal notion as a geographical principle.

Thus defined, geography has two chief divisions. Everything about the earth or any inorganic part of it, considered as an element of the environment by which the organic inhabitants are conditioned, belongs under physical geography or physiography.* Every item in which the organic inhabitants of the earth—plant, animal, or man—show a response to the elements of environment, belongs under organic geography. Geography proper involves a consideration of relations in which the things that belong under its two divisions are involved.

The validity of these propositions may be illustrated by a concrete case. The location and growth of Memphis, Helena, and Vicksburg are manifestly dependent on the places where the Missisippi river swings against the bluffs of the uplands on the east and west of its flood plain. The mere existence and location of the cities, stated independent of their controlling environment are empirical items of the organic part of geography, and these items fail to become truly geographic as long as they are stated without reference to their cause. The mere course of the Missisippi, independent of the organic consequences which it controls, is an empirical element of the inorganic part of geography, but it fails to become truly geographic as long as it is treated alone. The two kinds of facts must be combined in order to gain the real geographic flavor. Geography is therefore not simply a description of places; it is not simply an account of the earth *and* its inhabitants, each described independent of the other; it involves a relation of some element of physical geography to some item of organic geography, and nothing from which this relation is absent possesses the essential quality of geographical discipline. The location of a cape or of a city is an elementary fact which may

* It should be noted that the British definition of physiography gives it a much wider meaning than is here indicated.

be built up with other facts into a relation of full geographic meaning; but taken alone it has about the same rank in geography that spelling has in language. A map has about the same place in geography that a dictionary has in literature. The mean annual temperature of a given station, and the occurrence of a certain plant in a certain locality, are facts of kinds that must enter extensively into the relationships with which geography deals; but these facts, standing alone, are wanting in the essential quality of mature geographical science. Not only so; many facts of these kinds may, when treated in other relations, enter into other sciences; for it is not so much the thing that is studied as the relation in which it is studied that determines the science to which it belongs. I therefore emphasize again the broad general principle that mature scientific geography is essentially concerned with, the relations among its inorganic and organic elements; among the elements of physical and of organic geography; or, as might be said more briefly, among the elements of physiography and of ———. Let me confess to the most indulgent part of this audience that I have invented a one-word name for the organic part of geography, and have found it useful in thinking and writing and teaching; but inasmuch as the ten, or at the outside, twelve new words that I have introduced as technical terms into the growing subject of physiography have given me with some geological critics the reputation of being reckless in regard to terminology, it will be the part of prudence not to mention the new name for organic geography here, where my audience probably consists for the most part of geologists.

There can be no just complaint of narrowness in a science that has charge of all the relations among the elements of terrestrial environment and the items of organic response. Indeed the criticism usually made upon the subject thus defined is, as has already been pointed out, that it is too broad, too vaguely limited, and too much concerned with all sorts of things to have sufficient unity and coherence for a real science. Some persons indeed object that geography has no right to existence as a separate science; that it is chiefly a compound of parts of other sciences; but if it be defined as concerned with the relationships that have been just specified, these objections have little force. It is true indeed that the things with which geography must deal are dealt with in other sciences as well, but this is also the case with astronomy, physics, chemistry, geology, botany, zoology, history, economics. . . . There is no subject of study whose facts are independent of all other subjects; not only are the same things studied under different sciences, but every science employs some of the methods and results of other sciences. The individuality of a science depends not on its having to do with things that are cared for by no other science, nor on its employing methods that are used in no other science, but on its studying these things and employing these methods in order to gain its own well defined object. Chemistry, for example, is concerned with the study of material substances in relation to their constitution, but it constantly and most properly employs physical and mathematical methods in reaching its ends. Botanists and zoologists are much interested in the chemical composition and physical action of plants and animals, because the facts of composition and action enter so largely into the understanding of plants and animals considered as living beings. Overlappings of the kind thus indicated are common enough, and geography as well as other sciences exhibits them in abundance. It may be that geography has a greater amount of overlapping than any other science; but no valid objection to its content can be made on that ground; the maximum of overlapping must occur in one science or another—there can be no discredit to the science on that account. Geography has to do with rocks whose origin is studied in geology; with the currents of the atmosphere, whose processes exemplify general laws that are studied in physics; with plants and animals, whose forms and manner of growth are the first care of the botanist and the zoologist; and with man, whose actions recorded in order of time occupy the historian; but the particular point of view from which the geographer studies all these things makes them as much his own property as they are the property of any one else.

In view of what has been said let me return to the close scrutiny that I have urged as to what should be admitted within the walls of a geographical society. We will suppose the geography of Pennsylvania is under discussion; as a result there must be some mention of the occurrence of coal, because coal, now an element of inorganic environment,exerts a control over the distribution and the industries of the population of Pennsylvania. But the coal of Pennsylvania might be treated with equal appropriateness by a geologist, if its origin, its deformation and its erosion were considered as local elements in the history of the earth; by a chemist, if its composition were the first object of attention; by a botanist, if the ancient plants that produced the now inorganic coal-beds were studied. Furthermore, it would be eminently proper for the geologist to make some mention of the present uses to which coal is put; or for the chemist and the botanist to tell something of the geological date when coal was formed, if by so doing the attention of the hearer could be better gained and held, and if the problem at issue could thereby be made clearer and more serviceable. So the geographer is warranted in touching upon the composition, the origin, the exploitation of the Pennsylvania coal-beds, if by so doing he makes a more forcible presentation of his own problem; but if he weakens the presentation of his own problem by the introduction of these unessential facts, still more if he presents these unessential facts as his prime interest, he goes too far. The point of all this is that students in many different sciences may have to consider in common certain aspects of the problems presented by the coal of Pennsylvania; but that each student should consider Pennsylvania coal in the way that best serves his own subject. The scrutiny that I have urged would therefore be directed chiefly to excluding from consideration under geography the non-geographic relations of the many things that various sciences have to study in common, and to bringing forward in geography all the problems that are involved in the relations of the earth and its inhabitants. The things involved in the relations of earth and life are the common property of many sciences, but the relations belong essentially to geography. It would be easy to point out topics in text-books and treatises, in the pages of geographical journals, and in lectures before geographical societies, that would not fall under any division of geography as here defined. In many such cases, however, the topics might without difficulty have given a sufficiently geographical turn, had it been so desired or intended; the topics might have been presented from the geographical point of view, so as to emphasize the essential quality of geographical study, had there been a conscious wish to this end. But in other cases, the subjects presented belong so clearly elsewhere, or are treated so completely from some other than a geographical point of view, as to fall quite outside of geography; for example, a recent number of one of our geographical journals contained an excellent full page plate and a half page of text on the "Skull of the Imperial Mammoth," with brief description of its size and anatomy, but with nothing more nearly approaching geographical treatment than the statement that the specimen came from "the sands of western Texas." In all such cases it is open to question whether close scrutiny as to inclusion and exclusion has been given, and while the policy pursued by many geographical societies of generously accepting for their journals many sorts of interesting articles has something to commend it in the way of pleasing a mixed constituency, it is nevertheless open to the objection of not sufficiently advancing the more scientific aspects of geography. Blades of grass and mammoth skulls are very good things, if crops of hay and collections of fossils are to be gathered; but they are in the way of the growth of the best corn and of the publication of the best geographical journals. Let no one suppose, however, that the audiences in geographical lecture halls or the readers of geographical journals need suffer under the scrutiny that is here urged regarding lectures and articles. There is, even under the strictest scrutiny, an abundance of varied and interesting matter of a strictly geographical nature; few if any sciences are richer than geography in matter of general interest. There is indeed some reason for thinking that the real obstacle in the way of applying close scrutiny in the way here recommended, is the difficulty of obtaining high-grade material presented in an essentially geographical form. Inasmuch as this difficulty arises from the relative inattention to geography as a mature science, it is the business of geographical societies to remove the difficulty.

It has been maintained that one of the embarrassments from which geography suffers is the incoherence of the many things that are involved in its broad relationships. This is not really a serious embarrassment, and so far as it is an embarrassment at all it is not peculiar to geography. It is not a serious embarrassment, because when any element of geography is treated in view of the relations into which it enters, it becomes reasonably interesting to all who are concerned with scientific geography. The embarrassment is not peculiar to geography, for it is found in all other studies; in history, for example, where an essay by a specialist on the modern history of South America is not likely to excite an enthusiastic interest in the mind of the student of classic times in Greece, or in the mind of the student of mediæval church history in Germany; the embarrassment is known also in geology, where the student of the petrography of the southern Appalachians, or of the paleontology of the Trias in California, may care little for a paper by a colleague on the glaciation of the Tian Shan mountains in Turkestan. Yet, however unlike these various topics in history or in geology may be, they are welcomed, if well treated, by all the members of the expert society or by all the readers of the special journal in which they are presented, because they so manifestly make for progress in the science to which they belong. Geographers need not therefore be embarrassed on finding discussions of magnetic declination as affecting the navigation of the Antarctic regions, of the relations of climate and religion among the Hopi Amerinds, and of the facilities for irrigation peculiar to aggrading fluviatile plains, all in one journal; this diversity of topics only illustrates the great richness of geography, and thus likens it to history and geology.

Let me consider next the advantages that will come to geography from the systematic collection and classification of all the facts pertinent to it. The popular idea of geographical research is fulfilled when an explorer discovers a new mountain or a new island; but discovery is not enough. The thing discovered must be carefully described in view of all that is known of similar things, and the relation into which the thing enters must be sought and analyzed. Careful work of this nature involves the development of systematic geography, in which all items of a kind are brought together, and all kinds of items are arranged according to some serviceable scheme of classification. Geographers are far behind zoologists and botanists in this respect, for there is today no comprehensive scheme of geographical classification in general use. Existing schemes are too generally empirical and incomplete. So important a group of land forms as mountains has never yet been thoroughly treated in a physiographic sense, while the organic responses to inorganic controls are as a rule not classified by geographers at all; yet a comprehensive scheme of classification should certainly provide systematic places for the organic responses as carefully as for inorganic controls. In the absence of a generally accepted scheme of classification, it is natural that items of one kind and another should be neglected in text-books and elsewhere; for it is well known that incompleteness of treatment goes with unsystematic methods. So simple and manifest a response to the globular form of the earth as is afforded by the wide extent of modern commerce is seldom mentioned in conection with its control. The many important and interesting responses to the eternal and omnipresent force of gravity are not habitually treated as geographical topics at all; nor is the definition of boundaries in terms of meridians and parallels usually recognized as a response that civilized nations now habitually make to the form and rotation of the earth, when they have occasion to divide new territory in advance of surveys and settlement. Yet surely all these responses to environment deserve systematic mention when the earth is described as a rotating gravitating globe, just as the location of villages and the growth of cities at some point of advantage to their inhabitants deserves mention in the pages given up to geography of the more conventional kind. The development of a well-tested scheme of systematic geography may therefore be urged upon every geographer as a problem well worthy of his atention. A practical step toward the construction of such a scheme is evidently the accumulation of its items that call for classification; therefore, let the geographer study the world about him: and a most effectual aid in the accumulation of items is found in searching for the organic response to every organic control, and for the inorganic control of every inorganic response that comes to one's atention; therefore, let the geographer think carefully as he looks about him over the world. It can hardly be doubted that the explorer who goes abroad or the student who stays at home will make better progress in his investigations in proportion to the completeness of the systematic scheme with respect to which he consciously carries on his work. I would therefore urge the development of the habits of always associating causes with their consequences and consequences with their causes, and of always referring both causes and consequences to the classes in which they belong. If to these two habits we add a third, namely, that of making a careful arrangement of the classes in a reasonable and serviceable order, we shall have taken three important steps in geographical progress, and, as a result, geography will flourish.

There is no device by which the work of the specialist is so helpfully relieved of its narrowing influence as by the simple device of looking always for the general geographical relations of any special topic. The specialist in the geographical study of ocean currents, of caverns or of deltas, of forests, of trade routes, or of cities, should not lessen his attention to his chosen line of work, but he should, often to his great advantage, increase his attention to the place that his chosen subject holds in the whole content of geography. Not only will his work be broadened in this way, but both he and his work will be brought into closer relations with the whole body of geographers and the whole content of geography, and the possibility of organizing a society of mature geographical experts will be thereby greatly increased. If the geographical relations of a special topic are not looked for, the specialist fails to that extent of becoming a geographer. The climatologist who studies the physical conditions of the atmosphere for their own sake, the oceanographer who makes no application of the physical features of the ocean as controls of organic consequences, the geomorphist who is satisfied with the study of land forms as a finality, the student of the location of cities and the boundaries of states who makes no search for the explanation of his facts as affected by physiographic controls—these specialists may all be eminent in their own lines, but they fall short of being geographers. In the same way it might be shown that a petrographer who makes no study of field relations and discovers no results of processes and no sequences in time, fails of being a geologist, for geology deals essentially with processes and structures in time sequence; likewise a chronologist who is satisfied with mere dates of occurrence fails of being a historian, for history involves the meaning as well as the mere sequence of human events. There is, of course, no blame to be attached to interest in specialization, no praise to an interest in larger relations; it is merely a matter of fact that the isolated specialist remains somewhat to one side of the larger sciences with which he might become associated. On the other hand, the geographer is not necessarily so broad-minded that he must be shallow; he may specialize deeply on the climatologic, oceanographic, geomorphic, topographic, organic divisions of his subject; but if he wishes to be considered a geographer he should cultivate all the geographic relations into which the facts of his chosen division enters, and he will find that it is largely through these relations that he associates himself profitably with other geographers.

Two of the most beneficial results of the systematic study of geography are the great increase in the number of classes or types with which the geographer becomes familiar, and the great improvement in the definition of these types. This is particularly the case with those types which contain many individual examples, such as rivers and cities, and which are therefore capable of division into many headings. So long as the geographer deals only with things in an empirical fashion, he may be satisfied with a rough classification; as soon as he begins to treat his problems more carefully, his classification becomes more refined and he has relatively more to do with classes of things than with the things themselves. The things are actual, the classes are ideal, and therein lies one of the greatest values of systematic geography; it enforces attention upon the idealized type; by means of this increased attention the type is more fully conceived, and both observation and description of actual things are greatly aided. Let me illustrate.

The breezes that descend from mountain valleys at night are well known and well understood phenomena. As a result, one may form a well-defined conception of such a breeze—a type mountain breeze—imagining its gradual beginning, its increase in strength with its extension in area, and its gradual extinction; all its phases of waxing and waning being duly related to the passing hours of the night and to the associated changes of temperature. It is safe to say that no actual mountain breeze is as well known by direct observation of all its parts and stages as is the type breeze, in which all pertinent observations are properly generalized, and in which the deficiencies of observation are supplemented as far as possible by inferences deduced from well-established physical laws. It is entirely possible that there may be some errors in the deduced elements of the ideal type-breeze, but it may be confidently asserted that the errors will be replaced by the truth through the methods involved in observing, imagining, and checking, guided by the conception of the type, sooner than the truth will be discovered by blind observation unguided by the aid that a well-defined type affords.

It is the same with an alluvial fan; an element of land form that has, by the way, more similarity to a mountain breeze than appears on first thought. Observation shows only the existing stage of the surface of a fan; the fully developed type-fan includes the structure as well as the surface, the process and the progress of formation, extended into the future as well as brought forward from the past. There can be no question that the explorer who is equipped with a clear conception of a type-fan can do much better work in observing and describing the fans that he may find than will be done by an explorer who thinks he can dispense with all idealized types, and who proposes simply to describe what he sees. The shortcomings of the simple observational method would be less if it were not so difficult to see what one looks at and to record what one sees; but any one who has had experience in field studies knows how far short seeing may be of looking, and how far short recording may be of seeing. The best results in geographical investigation can only be obtained when every legitimate aid to observation and description is summoned; and, of all aids, that furnished by carefully considered types, reasonably classified, is the greatest. When large and complicated features, such as valley systems or cuestas, are to be described, the need of types is vastly increased. Hence one of the most important and practical suggestions that can be made toward the maturing of geographical science is to cultivate the geographical imagination in the direction of acquiring familiarity with a large, systematic series of well-defined ideal types. As progress is made in this direction there will be profitable advance from that narrow conception of geography which is based on the school-day study of names, locations and boundaries—the only conception of geography that many mature persons in this country possess—to a wider conception in which everything studied is considered as an example of a kind of things, so that it shall appeal to the reasonable understanding rather than to the empirical memory. Progress of this sort is already apparent in the schools, but it has not yet reached a desirable measure of advance.

One of the best results that will follow from the systematic recognition of a large number of well-defined types will be the natural development of an adequate geographical terminology. When review is made of modern geographical articles, it is curious and significant to find only a small addition to the school-boy list of technical terms. This is not true of any subject that is cultivated in the universities as well as in the schools. It is a reproach to geography that the results of mature observation are so generally described in the inadequate terms of immature study; this reproach will have the less ground the more thoroughly systematic geography is studied. With the development of more mature methods of description there may come a larger share of attention to the thing described, and thus a relative decrease of attention to matters of merely personal narrative. I do not wish to lessen the number of entertaining books of travel which now fill many of the shelves in libraries called geographical, but it would be a great satisfaction to see the standard works of geographical libraries given a more objective quality, so that they might compare favorably with the standard works of geological or botanical libraries, in which the element of personal narrative is reduced to its properly subordinate place.

Another step of equal importance with the establishment of geographical types is the change from the empirical to the explanatory or rational or genetic method of treating the elemental facts that enter into geographical relationships. The rational method has long been pursued in regard to the facts of the atmosphere and the ocean; it is coming to be adopted for facts concerning the lands; and since the adoption of an evolutionary philosophy, the evolutionary explanation of the organic items of geography may replace the teleological treatment that obtained in Ritter's time. It is, however, very seldom the case that geographers adopt the rational method consciously and fully; hence special attention to this phase of the theoretical side of geography may be strongly urged. It may be noted in this connection that the application of the explanatory method has been so lately made to the treatment of land forms that the geographer may for the present make himself to his advantage something of a specialist in this branch of the subject. It should be added that, so long as he studies land forms in order better to understand the environment in which living things find themselves, he remains a geographer and does not become a geologist. There is a needless confusion in this matter, which may perhaps be lessened if its untangling be illustrated by the following geological comparison.

For some decades past a new method of treatment has been applied to the study of rocks, greatly to the advantage of geologists. The method requires a good knowledge of inorganic chemistry and of optical physics, and the geologists who have specialized in the study of rocks have had to make themselves experts in these phases of physics and chemistry; but they are not for that reason classified as physicists or chemists. They remain geologists, though sometimes taking the special title of petrographer. So with the geographer who specializes in the study of land forms; he must make himself familiar with certain phases of geology, but he does not therefore become a geologist; he remains a geographer. His object is not to discover for their own sake the past stages through which existing land forms have been developed; he studies past forms only in order to extend his knowledge of systematic physiography and thus to increase his appreciation of existing forms. As far as he studies the sequence of past forms he is studying a phase of geology, just as the geologist who examines existing arrangements of climate, or oceanic circulation, or of land forms, is studying a phase of physiography. The two sciences are manifestly related, but they need not be confused. For, as has been shown for sciences in general, geology and geography are best characterized by the relations in which their topics are studied and not by the topics themselves. Both are concerned with the earth and life. The whole content of knowledge concerning the earth and life might be shown by a cube, in which vertical lines represented the passage of time, and horizontal planes represented phenomena considered in their areal extension; then if the whole mass of the cube were conceived as made up of vertical lines, that would suggest the geological conception of the whole problem: while if the cube were made up for horizontal planes, that would suggest its geographical aspect; and the whole series of paleogeographies, horizontally stratified with respect to the vertical time line, would culminate in the geography of today.

Objection is sometimes made to the plan of geography, as here set forth, that it involves hypotheses and theories, instead of being content with matters of fact, as the advocates of a more conservative method in geography suppose themselves to be. There is no doubt that geographical investigation of the kind here exposed does involve abundant theorizing, but that is one of its chief merits, for therein it adopts the methods of all inductive sciences. Furthermore, as between the progressive geographer, who candidly recognizes that he must theorize, and the conservative geographer, who thinks that he observes facts only and lets theories alone, the chief difference is not that the first one theorizes and the second does not, but that the first one knows when he is theorizing and takes care to separate his facts and his inferences, to theorize logically, to evaluate his results, while the second one theorizes unconsciously and hence uncritically, and therefore fails to separate his inferences sharply from his facts, and gives little attention to the evaluation of his results. Geography has indeed suffered so long and so seriously from the failure of geographers to cultivate the habit of theorizing as critically as the habit of observing—studies of the atmosphere and the ocean still excepted, as above—that a strong recommendation must be given to the acquisition of the methods of theoretical investigation, in which deduction is an essential part, by every one who proposes to call himself a scientific geographer. Let me give an example of the loss of time that has resulted from the failure of geographers to develop the habit of theorizing.

For forty years past there has been active discussion as to how far land forms in glaciated regions had been shaped by glacial erosion, but not till within five years has any geographer clearly defined the deductive side of this problem. In order to determine whether land forms are carved by glacial erosion or not, two methods have been open: one is to observe the action of existing glaciers and thus determine whether they are competent or not to carve land forms; but this is difficult, because the beds on which glaciers lie cannot be well examined. The other method is to deduce the appropriate consequences of both the affirmative and the negative suppositions, and then to confront these consequences with the facts found in regions once glaciated, and see which set of consequences is best supported. This deductive method is very simple. Its application involves no principle that was not perfectly well known fifty years ago, though it does involve a facility in theorizing that does not seem to have been familiar or habitual with geographers until recent times. On the supposition that glaciers do not erode, the valley systems of once glaciated mountains ought not to exhibit any significant peculiarity of form, but should correspond to the normal stream-worn valley systems of non-glaciated mountains. On the supposition that glaciers do erode, the valley systems of once glaciated mountains should exhibit the highly specialized feature of a discordant junction of branch and trunk; for the channels eroded by a small branch glacier and by a large trunk glacier must stand at discordant levels at their junction, just as the channels of a small stream and a large river do, though the measure of discordance is much greater in the channels of the clumsy, slow-moving ice-streams than in the channels of the nimble, quick-moving water-streams. There can be no question that these well specialized consequences, deduced from the postulate that glaciers can erode their channels, are much more accordant with the actual features of valley systems in once glaciated mountains than are the consequences deduced from the opposite postulate; but my reason for introducing this problem here is not to call attention to the value of "hanging valleys" in evidence of glacial erosion, as first clearly set forth by Gannett in 1898 in his account of Lake Chelan, but rather to point out how slow geographers have been to employ the deductive method in solving this long-vexed problem. The moral of this is that geographers as well as geologists, physicists, astronomers ought to have good training in scientific methods of investigation, in which all their faculties are employed in striving to reach the goal of full understanding, instead of depending so largely on the single faculty of observation.

Some may, however, object that the problem of glacial erosion, just touched upon, belongs exclusively to geology and not at all to geography. It belongs to both; its association will be determined by its application, as the following considerations will show. The accumulation of sand-dunes by wind action, the abrasion of sea-coasts by waves, the erosion of gorges by streams, the construction of volcanoes by eruptions now in progress, manifestly belong in the study of physical geography, in close association with the blowing of the winds, the rolling of the waves, the flowing of streams, and the outbursting of lavas and gases. Both the agent and the result of its action are elements of the environment by which life is conditioned. Similarly, the grass-covered dunes of Hungary, the elevated sea-cliffs of Scotland, the abandoned gorges of central New York, and the quiescent volcanoes of central France, are all elements of land forms and are all treated as geographical topics and explained by reference to their extinct causes in the modern rational method of geographical study. Likewise the discordant valley systems of glaciated mountains are proper subjects for explanatory treatment in the study of geography, although the glacier systems that eroded them are extinct; they deserve explanatory treatment in geography as fully as do the accordant valley systems of non-glaciated mountains. It is true that discussion as to whether certain sculptured land forms are due to glacial erosion is likely to continue more or less actively through the present decade; but when this problem is as well settled as the problem of stream erosion has already been, the geographer will be content with the simplest statement of the evidence that is essential to the conclusion reached; and the explanatory descriptions of land forms will include due reference to forms of glacial origin, just as much as a matter of course as they now include reference to forms of marine or of subaerial origin. Forms of glacial sculpture will be given as assured a place in geographical study as forms of glacial deposition are already given. Neither the thing studied, nor the agent by which it was produced, nor the method by which the agent is shown to be accountable for the thing, suffices to show whether the thing is of a geological or a geographical nature. This question will be decided, as has already been shown, by the relations into which the thing enters. It would be as unreasonable to omit all reference to glacial erosion in a geographical description of Norway as to omit all reference to subaerial erosion in a geographical account of our Atlantic coastal plain.

Nowhere is the cultivation of systematic geography more helpful than in the study of local or regional geography. The truth of this may be appreciated by considering the case of botany. No botanist would atempt to describe the flora of one of our states until he had obtained a good knowledge of systematic botany in general. Such knowledge would help him at every turn in his study of a local flora, not only in describing the plants that he might find, and in arranging the descriptions in a serviceable order, but also in finding the plants themselves. I believe that a closely equivalent statement might be made with regard to the geography of a state; and yet there is not, to my knowledge, a single work on regional geography in which a recognized scheme of systematic geography has been avowedly followed as a guide for the treatment of local features. The adoption of such a guide would lead to various advantages; on announcing that a certain scheme of systematic geography has been chosen as a standard, the writer of a regional work thereby gives notice in the simplest manner to the reader as to the kind and amount of knowledge necessary to understand the work in hand; descriptions are made at once briefer and more intelligible by phrasing them in terms of a scheme that is elsewhere stated in full; relative completeness of treatment is assured, for with a systematic list of all kinds of geographical relations at hand, the writer is not likely to overlook any element of the subject that occurs within his chosen region; the reader can easily find any desired topic, not only by means of the table of contents and index, but also by means of the standard scheme of classification in accordance with which all elements are arranged; and finally, books on different regions will come to exhibit a desirable uniformity of treatment, when they are based on a common scheme of systematic geography. Although no books of this kind now exist, I do not think it overventuresome to say that some such books will soon exist, and that they will form very serviceable contributions to the literature of our subject.

The various recommendations that I have made are likely to remain in the air, or at most to secure response only from isolated individual students, unless those who believe that the adoption of these recommendations would promote the scientific study of geography are willing to give something of their time and thought towards organizing a society of geographical experts—an American Geographers Union. From such a union I am sure that geography would gain strength, but it is not yet at all clear in my mind that any significant number of persons would care to accept the strict conditions of organization which appear to me essential for the success of such an enterprize. The most important of the conditions are as follows:

1st. The adoption of some definition for geography that shall sufficiently indicate the boundaries as well as the content of this broad subject.

2d. The limitation of membership to persons with whom geography as thus defined is a first or at least a second interest, and by whom more than one geographical article of advanced grade, based on original observation and study, has been published.

3d. The independence of the union thus constituted of all other geographical societies.

Although we cannot adduce any existing geographical society in this country as a witness competent to prove that geography has sufficient unity and coherence to tempt geographers to form such a union as is here contemplated, a careful review of the problem convinces me that a sufficient unity and coherence really exist in the science as I have here treated; and I believe that the formation of an American Geographers Union is feasible as well as desirable.

It has been my object in this address to describe briefly the status of mature geography in our country, and to suggest several steps that might be taken for its improvement. Certain branches of the subject have reached a high development, but the subject as a whole does not thrive with us. The reason for its relative failure is not, I believe, to be found in the very varied nature of its different parts, but rather in the failure to place sufficient emphasis on those relationships by which, more than by anything else, geography is to be distinguished from other sciences, and by which, more than by anything else, geographers may come to be united. Among the great number of persons—many thousands in all—whose attention is given primarily to subjects that are closely related to geography as here defined, there must certainly be many—probably several hundred—with whom mature scientific geography is a first interest. It is upon these persons, geographers by first intention, that the future development of sound and thorough, mature and scientific geography among us primarily depends. To these geographers in particular, I would urge the importance of developing the systematic aspects of the science, and of constantly associating the special branch that they cultivate with the subject as a whole. Observation will not suffice for the full development of geography; critical methods of investigation, in which deduction has a large place, must be employed; for only by the aid of careful theorizing can an understanding of many parts of the subject be gained. With the progress of systematic geography we may expect to see a parallel progress of local or regional geography. As the science is thus developed, societies of mature geographical experts will be formed, and scientific geography will thrive; but whether thus developed into a thriving science or not, I hope that another long term of years may not pass without a representative of geography in this vice-presidential chair.

EDITORIAL COMMENT.

WHERE DID LIFE BEGIN?*

The quest of the place of origin of the human race, the location of the Garden of Eden, and the beginning of life on the planet are not identical, but are so closely allied that the author of the first-mentioned of the works named includes the latter topic in his discussion. In several of his chapters Dr. Warren directs attention to the conditions favoring the commencement

* Paradise found; The cradle of the human race at the North Pole; A study of the prehistoric world. WM. F. WARREN. Boston. Houghton, Mifflin and Company, pp. 505. 1885.

"Where did Life begin?" A brief inquiry as to the probable place of beginning and the natural courses of migration therefrom of the Flora and Fauna of the earth. A monograph. By G. HILTON SCRIBNER, New York. Charles Scribner's Sons, 75 pp. 1903. New edition, price $1.20 net.

of life at the pole. See p. 59. Wallace (quoted by Warren) shows that the "facts of arctic paleontology call for the supposition of a primitive Eocene continent in the highest latitudes." Professor Heer of Zurich noted the same. Baron Nordenskjöld arrived at the same conclusion. J. Starkie Gardner argued from the facts known then (1878) that continuous land once united Europe and North America. This arctic continent, whether it was that which was submerged by the ocean that covered northern Asia as shown by professor G. F. Wright, in late Glacial or post-Glacial time, or was that which gave birth to the great glaciers of the Glacial epoch, subsisted through the Tertiary, since fossil Tertiary land plants, indicating warm and moist climates, have been found at numerous points within the Arctic circle. Given this continent and the tropical warmth that its fossils denote, the great preponderance of light over darkness, the intensity of direct, continued sun's rays, and the conditions were favorable for the most luxuriant, if not for spontaneous, life. It is now a well-known doctrine of fossil botanists that the oldest land plants of the earth originated in the region of the North pole and from there spread southwardly. This evolution toward the south continued. That the Arctic region was the birth place of plants and continued to send her progeny southward until the close of the Tertiary has been demonstrated by Gray, Heer, Hooker, Kuntze, Saporta and others.

With the existence of such a continent at the north pole, and with the demonstrated stream of migratory plant life emerging from it, the author does not fail to inquire as to the evidence of animal origin in the same region. He quotes Orton (1876) and Wallace (1876) to the effect that the north temperate and Arctic regions have been the starting-points of long continued migrations and concludes this branch of his inquiry in the following words: "From all the facts but one conclusion is possible, and that is that like as the Arctic pole is the mother region of all plants, so it is the mother region of all animals—the region where, in the beginning God created every beast of the earth after its kind, and cattle after their kind. And this is the conclusion now being reached and announced by all comparative zoologists who busy themselves with the problem of the origin and prehistoric distribution of the animal world. But to believe that professor Heer's Miocene arctic continent was the cradle of all floral types and the cradle of all faunal forms, and yet to deny that it was also the cradle of the human race, is what few philosophical minds are likely long to do."

Dr. Warren enters upon a long research in ancient literature, both anthropological, ethnological, traditional and mythological, with a wonderful sweep of classical lore, tending to show that the earliest ancients possesssed some knowledge of their origin at the north, and traditions, both biblical and profane which when correctly understood point to the same conclusion. His first printed announcement of this result appeared in the *Boston Daily Advertiser,* of May 25, 1883. This view had, however, been presented in lectures for some years previous, based on the foregoing evidences.

Mr. Scribner's volume in its first edition appeared in 1883, and Dr. Warren was then in the midst of composing his final treatise. A copy was sent to Dr. Warren, who at once made extended extracts from it as accordant with his own views. There is no doubt that his publication on this topic preceded the incidental allusion to the commencement of life at the pole by Dr. Warren as published in "Paradise Found," but the earlier publications by Dr. Warren "in a printed essay," and his lectures to the students for a year previous must have covered the same ground. This is also in keeping with Dr. Warren's statement (p. 103) where he says: "As Mr. Scribner was conducted to a belief in the north polar origin of all races of living creatures by considerations quite independent of those mythological and historical ones which first led the present writer to the same opinion, the reader of these pages will find in the following extracts a special incentive to procure and read the entire treatise from which they are taken. That two minds starting with such entirely different data should have reached so nearly simultaneously one and the same conclusion touching so difficult and many-sided a problem is surely not without significance." This preliminary remark is due here to the earlier conception, if not publication, of Dr. Warren, since not only Mr. Scribner in his preface, but professor J. L. Wortman in the appendix, (quoted from Am. Jour. Sci.., June, 1903) seem to be ignorant of Warren's views and the date of their publication.

Mr. Scribner's argument is wholly along lines of physical geology and physiography. Assuming the early geological climates to have been as they are now, governed by solar radiaton, he shows that in the cooling of a heated globe the first part to become cool enough to be habitable was at the pole. This is the central idea of the treatise. If it should appear that the early geological climates were not sun-controlled, but earth controlled, according to the theory of Manson, and the sun's rays were excluded by an encompassing mantle of cloud, it is probable, as admitted by the author, that all parts of the earth would arrive at about the same time to so cool a condition as to be life-bearing. The author dismisses this idea as absurd, the mere statement of which furnishes its own refutation.

The author of each of these treatises leaps from "origin of life at the pole" to the discussion of the migrations of Tertiary and Pleistocene life, apparently not sufficiently realizing that the later migrations, which are now well known to have been from north to south, may have had no relation to earlier migrations, and do not at all show the place of the beginning of life on the globe. There was an immensely long period, constituting far the larger part of geological history as marked by paleontology, which is thus omitted from the discussion. Whether those earliest migrations were governed by the slowly southward cooling surface, and moved from north to south under that impulse we do not know. There are indeed some evidences that in the Devonian as well as in the Carboniferous the Arctic was as well adapted to the fossils characteristic of those systems as was the temperate zone. The same is true of the Tertiary. Indeed, so far as known, it is true of all the earlier ages, i.e. in general terms. Professor Wortman, however, finds that comparative studies of the temperate and arctic plants and animals indicate a gradual change from tropical and subtropical to temperate climate progressive from north to south, up to the Glacial epoch. The great migration southward at the time of the Glacial epoch, accompanied by the annhilation of many species, has a special cause and can hardly be taken into the same category. Yet it is the later, and the latest, of these movements that the authors appeal to chiefly to prove that life *began* at the pole and spread therefrom over the contitnents. There is apparently in the argument an instance of *non-sequitur*—although perhaps a probability on the assumption of identity or similarity of geological solar climates with those of the present.

Professor Wortman suggests that the hypothesis of the origin of life at the poles "should be known as the Scribnerian theory of the place of the origin of life," on the assumption that Mr. Scribner was the first to propose it. Aside, however, from the nearly simultaneous publication by Dr. Warren, it is admitted by Dr. Warren (p. 59) that professor Philip Spiller in 1868 and 1873 published "identical reasonings."

N. H. W.

CHARLES EMERSON BEECHER.

It becomes our painful duty to record again the death of one of our editors. At this writing we know nothing of the details of Dr. Beecher's death. The telegraphic despatches of our daily papers have made the bare announcement. He was born October 9th, 1856, at Dunkirk, N. Y., and died February 14th, 1904, at New Haven, Connecticut.

He was professor of paleontology and curator of the geological collections of Yale University. He graduated at the University of Michigan in 1878; received the degree of doctor of philosophy from Yale in 1889; he married September 12th, 1894, Mary Salome Galligan. He was the author of "Studies in Evolution," 1901, one of the Yale bicentennial publications, and of many papers in scientific journals and proceedings of scientific societies, principally on modern evolution and the classification of brachiopods and trilobites, and on the development and detailed structure of trilobites etc., a number of which have appeared in the AMERICAN GEOLOGIST. His loss is a very severe blow to American paleontology.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Evolution of Earth-Structure, with a Theory of Geomorphic Changes. T. MELLARD READE. 40 plates. 342 pages. Longmans, Green and Co., London, New York and Bombay. 1903. $7.00; by mail, $7.22.

The author of this volume here presents not only some of his views of the cause of the features of the surface of the earth, some of which are well known through his earlier volume, "Origin of Mountain Ranges," but also gives the details of experiments conducted by himself upon artificial plates of various kinds designed to show the effect of compression comparable to that exerted naturally in the rocks of the earth's crust.

Mountain ranges are the result, according to Mr. Reade, of lateral compression due to cumulative recurrent expansion in regions of great sedimentary loading. But the continental areas are produced and maintained by a different force. He shows clearly that the theory of isostasy will not account for the rise or depression of the continental plateaus. It is even more clear that the action of lateral thrust, which causes mountain ranges, does not maintain the continents in their position above the oceanic basins. The author's view is that the continents stand higher because of lower specific gravity than the crust below the oceans. This difference of specific gravity causes the lighter rocks to float, as it were, like a cork on water, but is not due to a difference of mineral composition. Mr. Reade argues that there is a sort of pulsation in the interior of the earth by reason of which the internal heat rises towards the surface and recedes again at long and irregular intervals, sometimes heating the crust say of the North American continent, causing it to rise, and again allowing it to cool and contract, and hence to be slightly depressed again. The loci of heated areas shift from place to place, but they always cause an expansion and hence an elevation. It is hence still a species of isostasy to which Mr. Reade appeals, but not one that is affected by sedimentary loading.

Per contra the oceanic "deeps' ' are due to greater cold and hence to greater density. They therefore sink under the same law that causes the continents to rise. If the bottoms of the ocean be affected by any of these shifting heat-loci they expand, rise, thrust the oceans upon the land and perhaps inaugurate new geological epochs or systems. Their shrinkage again causes the uncovering of the lands and their more rapid denudation.

Mr. Reade's conclusions are the result of long study, and of great familiarity with American and English geological literature, and are worthy of the most careful attention. There is, however, an obstacle in the application of the theory, at the outset, which Mr. Reade does not consider. He speaks of the downward increase of heat in the earth's crust, and infers great heat a some depth. Why the rocky crust underlying the ocean so far as affected by internal heat should be colder than that of the continent he does not explain. Such ocean beds may be, and are, several miles nearer the great supply of internal heat than the continental areas, and according to the law of downward increase they would be expected to be warmer than the continental areas. We have read the volume entire with attention and have not found any allusion to this greater exposure of the oceanic "deeps" to the heated interior. Nor do we find any cause assigned for the assumed migration of the heated loci. As a hypothesis, however, Mr. Rheade is not required to prove its main assumption.

In the appendix the author gives some very interesting and valuable facts and figures as to the rate of denudation of continents, particularly the American continent, and on the Atlantic as a geological basin. These are from addresses which, as president, he has given before the Liverpool Geological Society. American geologists will be glad to have them in this form. N. H. W.

The Planetary System: A Study of Its Structure and Growth. FRANK BURSLEY TAYLOR. pp. 278. Published by the author, Fort Wayne, Ind. London, C. D. Cazenove and Son, 26 Henrietta Streea, Convent Garden. By mail, $1.60.

American geologists may not be surprised that another glacialist has found reason to study astronomy. The fascinating book of Mr. Taylor needs to be read to be appreciated. He discards the nebular hypothesis and argues from the standpoint of growth of planets by accretions of meteoric matter from without. He considers Bode's law of the spacing of the planets in their orbital distances from the sun one of the greatest contributions to theoretical astronomy. He applies it also to the placing of the satelites. The satelites he assumes are captured comets. The planets themselves are comets captured by the sun, but later enlarged. They never separated from the sun nor from the sun's fire mist by the ring method of La Place. When a new planet is added to the system it is placed on an orbit nearest the sun. Mercury is the latest accession to the Sun's family. When it took its place all the other planets were forced each one step (in Bode's law) further away from the sun. Each planet is supposed to have held in succession the orbital position of Mercury, at the "inner limit of stability," and to have been driven further away from the sun by the advent of new planets. When the solar system became "complete," each addition caused the loss of the outermost planet, which wandered off as a comet and may have gone to other suns, or as a comet it may have resumed the "first planetary place" nearest the sun, in its own system.

It was when Jupiter was nearest the sun that a great storm occurred —a storm of comets, a veritable rain of fire. When the heavens cleared and the usual quiet returned it was found that a group of small planets had taken their places within the orbit of Jupiter and made revolution about the sun in their individual orbits. Jupiter and all the outer planets were forced to enlarge their orbits and allow the asteroids to occupy the "first planetary position." This storm not only added the asteroids to the sun's retinue, but added immensely to the size of the planets, and most of all to the size of the sun. Jupiter, from being a planet about the size of the earth, grew to what he is at the present time, and the other planets in similar ratio, in proportion to their distances from the storm centre. This was not a violent and cyclonic storm, but probably lasted many thousands of years, and the falling comets were small. Saturn's rings are "a lingering fragment of the great comet storm." Since the comet storm the inferior planets have been added in succession, each taking its place first nearest the sun and afterwards being forced farther and farther away by later additions. These new planets are captured comets.

One is tempted to compare this book with the wild and impossible romances of Jules Verne, but such a comparison would be unjust, for Mr. Taylor keeps within the laws of physics, and he treads with the confident step of a giant amongst the great problems of physical astronomy with which he manifests a friendly familiarity. The late Alexander Winchell affirmed, on his death bed, that he believed and thought he could prove mathematically, that the planets had all been in succession removed in their orbits farther and farther from the sun from time to time. The present writer has recorded that statement in a biographical sketch published in the AMERICAN GEOLOGIST in February, 1892, p. 72. But he could not have derived that opinion from any such process of philosophy as presented by Mr. Taylor, for he was an adherent and defender of the nebular theory. N. H. W.

Les Roches Alcalines caracterisant la Province Petrographique d'Ampasindava Deuxiene Memoire par A. LACROIX. (Nouvelles Archives du Muséum d'Histoire Naturelle, 4th Series, Vol. V. 4to, 85 pages and 8 plates, Paris, 1903).

The first memoir on this subject appeared in two parts about a year ago; both parts were briefly reviewed in the GEOLOGIST (Vol. XXX. p. 328 and Vol XXXI. p. 183).

The second memoir is also to appear in two parts; the first part only has appeared; it is devoted to a detailed description of many more samples of the important series of highly alkaline igneous rocks. The second part is to be devoted to a discussion of the questions affected by the study of this important petrographic province.

The location of this province is in the northern end of the island of Madagascar; the eruptive rocks of the region are all post-Liassic in age. The particular localities whence the rocks are derived determine the division of the memoir into three chapters as follows:—Chapter I. The *massif* of Bezavąna. Chapter II. Localities east and southeast of Bezavana in the region of Ankaramy. Chapter III. The alkaline granites of Ampasibitika. In the first chapter the following rocks are described:—1. Syenytes without nepheline. 2. Nepheline syenytes. 3. Nepheline monzanytes. 4. Related dike rocks. 5. The contact phenomena of the nepheline syenytes. 6. Proterobases.

The contact phenomena of highly alkaline rocks are of extreme interest and importance to the petrographer. The introduction of alkalies in all the metamorphosed sediments is made manifest by the abundance of orthoclase. In certain cases the evidence is still better; in one of the samples studied the feldspathic hornstone is separated from the syenyte by a melanocratic zone in which the pyroxene is no longer ægirine-augite, but ægirine, accompanied by small crystals of arfvedsonite. Lacroix remarks (p. 216) that: "If one did not find all possible gradations between this rock so full of ægirine and the hornstone (cornéenne) of characteristic structure, one would be tempted to compare it with the ægirine schists described by Brögger as a varying facies of the nepheline syenyte of Grass-Aro."

In chapter three contact phenomena of highly alkaline granites are described. They are characterized especially by the introduction of foreign elements into the Liassic sediments; the fact that foreign elements have been introduced is rendered particularly clear by the nature of the minerals developed in the sandstones and modified schists; besides orthoclase there are minerals rich in soda, namely, ægirine, riebeckite and arfvedsonite, which are not commonly found as the product of contact metamorphism. But these alkaline minerals are precisely those which characterize the eruptive rock itself, and the pre-existence in normal sediments of all the elements necessary for their formation cannot be held as probable The author calls attention further to the importance of his discovery of fluorite as a mineral regularly distributed in a metamorphic rock of the region; the mineral has not heretofore been described in this rôle.

In chapter four, which is devoted chiefly to a summary statement, it is stated that one of the clearest results of the study is the establishment of the identity of the rock family called by the author nepheline monzonytes. It is the type intermediate between the nepheline syenytes and nepheline gabbros, and is characterized by the association of nepheline with alkaline and basic feldspars It is also worthy of note that barkevikite seems to be the normal pyroxene of the type.

Finally, it is worthy of remark that the author has described in some detail an unusually large number of rare and unknown minerals, such as eudyalite, catapléite, rinkite, and others unnamed. A. N. W.

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CORRESPONDENCE.

DIRECTION OF PREGLACIAL STREAM-FLOW IN CENTRAL NEW YORK. Under the above title in Vol. XXXIII, No. 1, p. 43, of this magazine, I am taken to task by professor Fairchild for an error which he says appears in my article, "A Type Case in Diversion of Drainage," Vol. 2, No. 3, Journal of Geography.

My article was published "for the purpose of suggesting to grammar and high school teachers the possibility of investigating similar cases in their own localities";* it makes no pretensions at treating the subject exhaustively, but states that "a discussion of the further conditions which figured in the establishment of the Blodgett Mills outlet

* *Journal of Geography*, vol. ii, No. 3, p. 116.

for the drainage that once belonged to Fall Creek would lead this paper beyond its initial purpose."*

It should be explained in justice to professor Fairchild, that my paper was the result not of a "study of stream directions and present contours on topographic maps", but of detailed work on foot extending over a period of nearly three years. For some time while working on the problem, I had but two sheets, the Dryden and Moravian quadrangles.

To summarize professor Fairchild's criticism:

1. He states that I make the valley of Fall creek a preglacial river, "debouching into Cayuga valley by the present Fall creek channel."

2. That I have overlooked "one principle and one fact" which show "that no considerable preglacial stream could possibly have followed the course given in his map." And that "as a matter of simple fact there is no such tributary valley joining the Cayuga valley at Ithaca."

3. "Nor is there any buried or deserted valley which could have been the product of the hypothetical stream."

4. And that "the reference to the 'moraine of the second glacial epoch' is untimely since the moraine in question belongs to the Wisconsin,' now regarded as at least the fifth epoch of glaciation."

As to No. 1:

I do make the Fall creek valley the product of a southwest flowing preglacial stream. I am not able, however, on reading my article again, to find any statement which warrants even the inference that this preglacial stream debouched "into Cayuga valley by the present Fall creek channel." The present Fall creek channel is a post-glacial gorge; incidental to this gorge are buried gorges, the episodes of inter- or immediately pre-glacial drainage.

As to No. 2:

The principle overlooked is that a mature stream attains grade. In answer I would quote from my article: "the region is quite mature in its drainage development."† One not familiar with the region may by consulting the topographic sheets verify the stage of development attained; the rock-in-place topography, save in the broad, drift filled valleys, is revealed with approximate accuracy by these sheets. Whatever may have been the preglacial condition in the north [illegible] Cayuga valley, the grade of the Fall creek stream had been adjusted to it as it had also the grade of Six Mile creek. But as a matter of simple fact there is no such tributary valley joining the Cayuga valley at Ithaca [illegible] the existence of such a valley is as obvious to me as its non-existence is simple to professor Fairchild. A half hour walk from the Cornell campus would convince anyone of the existence of this valley. The attitude of Fall creek in reference to Cayuga valley is by no means unique; the [illegible] may be [illegible] in Cayuga as well as in the Seneca valley by [illegible]

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* *Journal of Geography* vol. ii No. 3 p. 124

† *Journal of Geography* vol. ii No. 3 p. 118.

valleys; this point will be elaborated by professor Tarr, who intends to publish shortly on the drainage of this region.

As to No. 3:

There is a partially buried and deserted valley; its existence is a most obvious topographic feature to one in going northeast from Ithaca towards Freeville; it is not a synclinal fold, nor the resultant of any other epeirogenic action; it is due to stream action.

As to No. 4:

Professor Fairchild through an inadvertant misplacing of one quotation mark makes my acquaintance with the literature of glacial geology appear a little obsolete. I offer no excuse, however, for referring the teachers of our schools to the classic work of Chamberlin in the Third Annual report of the U. S. Geol. Survey. FRANK CARNEY.

Ithaca, N. Y.

NODULAR BARITE AND SELENITE CRYSTALS OF MONTANA. Much has been written concerning certain minerals and commercial ores of Montana, especially those of gold, silver, and copper, but in many respects a virgin field remains. During the writer's summer geological survey trip for the State University many very choice crystals of selenite and several pounds of quite pure barite were collected. While this material is not in large enough quantities to be of economic value, it is nevertheless of scientific interest.

The selenite crystals occur in the Laramie clays just below a small seam of lignite, and are as beautiful and perfect as those found in any locality. Selenite is found almost everywhere in the eastern half of Montana in the Upper Cretaceous formations, but, as far as the writer now knows, no other place in the state yields the crystals. These crystals are common 3½ miles south of Wiboux, Montana, on the east bank of Beaver creek on the Homer Speyer's ranch. They are for the most part exposed in the little rain-eroded ditches lying on the surface.

The length of the crystal-bearing clay is about 500 yards and in thickness about 10 feet. Many twins occur, and besides these four distinct forms are noted. Dana mentions in his mineralogy that selenite is "common in isolated crystals and masses, in Cretaceous clays in the western United States,"but does not give a specific locality.

Several chemical analyses were made of this selenite and two of the results are given below:

I. *Analysis.*	II. *Analysis.*
H_2O = 20.02 per cent.	H_2O = 20.08 per cent.
CaO = 32.86 per cent.	CaO = 32.86 per cent.
SO_3 = 46.95 per cent.	SO_3 = 46.94 per cent.
Total = 99.83 per cent.	Total = 99.88 per cent.

The barite found in the state is from several localities. The massive is principally from the Ruby mountains, Madison county; the nodular is from the head of Cabin creek, 23 miles south and east of Ekalaka, Custer county, in the Fox Hills formation; and the crystals about 25 miles from the mouth of Cedar creek, Dawson county, also in the Fox Hills formation. Only one piece was found in perfect crystals. This piece is a large radiating nodule. The crystals very much resemble the barite of South Dakota. They have a wine color and belong to the orthorhombic system. Their length is from 6 to 8 centimeters and about 1 centimeter thick.

The kind principally found is nodular-radiated fibrous. Their shape is spheroidal. A whitish blue color and a specific gravity of 4.7 nearly. Some of the nodules are from 5 to 10 centimeters in diameter and 3 to 7 centimeters thick. They are quite abundant at the head of Cabin creek and always occur with selenite, in clay. One stratum was very productive and was traced for over a half mile.

Several chemical analyses were made of the nodular barite with the following result:

Analysis.

$BaO = 65.60$ per cent.
$SO_3 = 34.32$ per cent.

Total $= 99.92$ per cent.

The chemical analyses were made by Mr. Martin Jones, B. S., graduate student in mineralogy. J. P. ROWE.

Missoula, Mont.

PERSONAL AND SCIENTIFIC NEWS.

DR. E. R. BUCKLEY will give a series of lectures at Chicago University on economic geology.

DR. W. S. BAYLEY has resigned the professorship of geology and mineralogy at Colby College, Waterville, Maine.

PROFESSOR N. S. SHALER of Harvard University will spend the next four months abroad, traveling in Egypt, Asia Minor and Greece.—*Science.*

THE GEOLOGICAL SURVEY OF CANADA has recently issued a series of ten geological sheets, Nova Scotia, referring to part P, vol. 5, annual report for 1890-91, by Hugh Fletcher.

MR. WALDEMAR LINDGREN has returned from Australia, and is now in active charge of the new survey of the mining district of Cripple creek for the U. S. Geological Survey.

PROFESSOR H. S. WILLIAMS has been offered and has accepted the position of professor and head of the department of geology at Cornell University, Ithaca, N. Y. He left Ithaca and went to Yale in 1892.

THE AGE OF THE GYPSUM OF CENTRAL IOWA is considered Permian by F. A. Wilder, after an elaborate discussion in the *Journal of Geology,* "though the possibility of its being Triassic cannot be denied."

PROFESSOR ALFRED LACROIX was recently elected a member of the Academy of Science at Paris in the vacancy created by the death of Meunier-Chalmas. His election was by a majority of sixty-eight to eight.

AMERICAN INSTITUTE OF MINING ENGINEERS. The meeting of February 16th to 19th, which was to be held in Baltimore, was transferred to Atlantic City on account of the recent disastrous conflagration in the former city.

AT A MEETING OF THE APPALACHIAN MOUNTAIN CLUB on the evening of Feb. 9, professor Davis of Harvard University gave an account of his last summer's trip through southwestern Asia. He had a large and enthusiastic audience.

A HALF TON OF TIN ORE has been brought from the tin-bearing dike lately discovered in Seward peninsula by Dr. Alfred H. Brooks of the United States Geological Survey. It is owned by Hon. Jos. H. Hutchinson of Boise, Idaho, who exhibited it at that place.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of January 27th the following program was presented: "Miocene of Maryland and its relation to other Miocene deposits," William H. Dall; "A Californian Tertiary coral reef and its bearings on the recent coral faunas of America," T. Wayland Vaughan; "The faunal relations of the Cattizo Creek beds of California," Ralph Arnold. At the meeting of February 10th the following program was presented: "Model of Alaska," Alfred H. Brooks; "Recent elevations and depressions in the Bahama islands," George B. Shattuck; "Domes and dome structure in the Sierra Nevada," G. K. Gilbert.

GEOLOGICAL EXCURSION IN MISSOURI. Following the meeting of the Geological Society of America at St. Louis several Fellows participated in a complimentary excursion to the lead and zinc mines of Missouri, given by the State Bureau of Mines with the co-operation of the railroad companies. The trip covered three days and was admirably planned and conducted by Dr. E. R. Buckley, state geologist. In spite of the unusually cold weather the excursion was highly successful and exceedingly satisfactory to all concerned. In the disseminated lead district of eastern Missouri the party was entertained by the mining companies at Bonne Terre, Doe Run and Flat River. In the zinc district visits were made to Joplin, Webb City and Carthage, the party being entertained by the Commercial clubs of those cities. Several mines were explored and reduction works examined. A special Pullman car was occupied by the party during the whole journey.

Besides the officials of the State Bureau of Mines, of the railroads and representatives of the press, the following G. S. A. Fellows were guests: F. D. Adams, Robert Bell, A. P. Coleman, A. R. Crook, H. L. Fairchild, N. M. Fenneman, C. H. Hitchcock, C. K. Leith, C. F. Marbut, A. M. Miller, W. G. Miller, F. L. Ransome, E. M. Shepard, E. A. Smith, I. C. White.

EDMUND ANDREWS.

Dr. Edmund Andrews died at Mercy Hospital, Chicago, on January 22nd. He was born at Putney, Vermont, on April 22nd, 1824; he graduated from the University of Michigan and was chief surgeon at camp Douglas during the civil war, after which he settled in Chicago and was a practicing physician and surgeon there until the time of his death. Dr. Andrews early became interested in geological phenomena and was especially interested in glacial deposits, on which he published several papers, as listed below; in 1874 he presented a paper on a theory of geyser action before the American Association for the Advancement of Science. The chief geological work for which he will be remembered is his paper on "The North American lakes, considered as chronometers of post-glacial time," which was published in 1870. In this he brought forward evidence as to the time required to form the various beaches at the south end of lake Michigan and from this a calculation as to the length of time which has elapsed since the end of the Glacial period. Dr. Andrews was one of the founders of the Chicago Academy of Sciences and has served as president of that society; he was also one of the founders of the Chicago Medical College, which later became the Medical School of Northwestern University and with which he was connected at the time of his death. Dr. Andrews' papers which relate to geological subjects are as follows:

Observations upon the glacial drift beneath the bed of lake Michigan, as seen in the Chicago tunnel. Amer. Jour. Sci., 2nd ser., vol. 43, pp. 75-77, 1867.

Reexamination of the localities of human antiquities at Abbeville, Amiens, and Villeneuve. Amer. Jour. Sci., 2nd ser., vol. 45, pp. 180-190, 1868.

On some remarkable relations and characters of the western boulder drift. Amer. Jour. Sci., 2nd ser., vol. 48, pp. 172-179, 1869.

The North American lakes, considered as chronometers of post-glacial time. Chicago Acad. Sci., Trans., vol. 2, no. 1, pp. 1-23, pl. 1, 1870.

New theory of geyser-action as illustrated by an artificial geyser. A. A. A. S., Proc., vol. 22, pt. 1, pp. 115-118, 1874.

Dr. Koch and the Missouri mastodon. Amer. Jour Sci, 3rd ser. vol. 10, pp. 32-34, 1875.

Glacial markings of unusual forms in the Laurentian hills. Chicago Acad. Sci., Bull., vol. 1, no. 1, pp. 1-9, 1883.

Glacial markings of unusual form in the Laurentian hills. Amer. Jour. Sci., 3rd ser., vol. 26, pp. 99-105, 1883.

UNITED STATES GEOLOGICAL SURVEY.

During 1903 parts of the coal fields of Pennsylvania included in Indiana, Cambria and Clearfield counties were studied by parties of the Survey. The area thus studied comprises the Ebensburg, Barnesboro, Patton and Curwensville quadrangles.

Accompanying the work done on the Alaska-Treadwell group of mines by A. C. Spencer, assisted by C. W. Wright, was a study of the district adjacent to Juneau, Alaska. The results of this reconnaissance will be published in the form of a short description accompanying a general geological map of the main-land strip between salt water and the International boundary. This map will cover the region extending from near Port Houghton to the head of Lynn canal, and will include the Porcupine placer district, which covers an area about 200 miles long, with an average width of about 50 miles. Both silver and gold ores occur at many places throughout this belt, which is possibly the northern extension of the metalliferous zone of the Ketchikan mining district, upon which a report has already been published by the Survey. South of Juneau the main developments are at Windham bay, Sundam, and Port Snettisham, while to the north there are active camps on McGinnis, Montana and Windfall creeks, on Eagle river and Cowee creek, south of Berners bay, with Jualin and Comet on the peninsula between that bay and Lynn canal.

The topography of the Catskill mountains is shown on the Gilboa and Rosendale quadrangles, recently issued, and on the Kaaterskill quadrangle which has been reprinted.

The Hartford, N. Y., quadrangle has been recently published.

The twenty-fourth annual report of the director of the Survey is now ready for distribution.

Professional Paper No. 18 on "Chemical Composition of igneous rocks, expressed by means of diagrams, with reference to rock classification on a quantitative chemico-mineralogical basis," by J. P. Iddings, is also ready for distribution.

Among the topographic maps recently issued are those of Holidaysburg, Pa., Everett, Pa., and Kenley, N. C.

Prospecting for the precious metals, with considerable excitement, in the Wichita mountains of Oklahoma was carried on last year, and late in the summer the district was examined by H. Foster Bain. The results of the assays of samples collected from many prospects show no encouragement whatever for deposits of economic importance of gold, silver and copper. Some columbite was found, and, as this mineral frequently accomanies others containing some of the rare earths, there is some hope that some of these minerals may later be discovered in the district.

Among the recently issued publications of the Survey are: Professional Paper No. 19, "Contributions to the geology of

Washington," by G. I. Smith and Bailey Willis; Bulletin No. 221, "Bibliography and index of North American geology, paleontology, petrology and mineralogy for 1902," by F. B. Weeks; Professional Paper No. 17, "Geology and water resources of western Nebraska," by N. H. Darton; Water Supply and Irrigation Paper No. 89, "Water Resources of the Salinas valley, California," by Homer Hamlin.

THE ST. LOUIS MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA. The recent meeting, December 30 to January 1, was quite up to the average attendance, although the American Association meeting was small. The registration was forty-nine without including the Fellows-elect or the candidates who were present. There was an unusually large representation of the Fellows from the Mississippi valley states. Memorials were read of J. P. Lesley and Peter Neff, but in the absence of the author the memorial of W. C. Knight was not presented. Besides the president's address the program included thirty-eight papers, of which ten were read by title. Section E completed its work on Tuesday and the Geological Society occupied the three days following, except Thursday afternoon, which was spent in a visit to the Exposition grounds and buildings.

The customary dinner was on Wednesday evening at the Planters hotel, but without speeches, and was followed by President Emmons' address, "Theories of Ore Deposition; historically considered." This was given in the large parlor of the hotel and was succeeded by a social reunion.

It has been decided to hold no summer meeting this year, and to meet with the A. A. A. S. at Philadelphia in December. The president for 1904 is professor J. C. Branner, Leland Stanford University, California.

The following is the list of papers presented.

AREAL.

OLIVER C. FARRINGTON—Observations on the geography and geology of western Mexico. (15 minutes, lantern views.)

C. H. HITCHCOCK—New studies in the Ammonoosac district of New Hampshire. (30 minutes.)

C ARLES R. DRYER—Studies in the western Finger Lake region. (20 minutes, lantern views.)

N. H. WINCHELL—Note on the geology of the Hellgate valley between Missoula and Elliston, and northward to Placid Lake, in Montana. (25 minutes.) By title.

PALEONTOLOGICAL.

ALEXIS A. JULIEN—A fossil water fungus in petrified wood from Egypt. (Read by title.)

J. E. DUERDEN (introduced by G. B. Shattuck)—The development and relationships of the Rugosa. (20 minutes.) By title.

PETROGRAPHICAL.

A. P. COLEMAN—The Sudbury nickel-bearing eruptive. (20 minutes.)

SAMUEL WEIDMAN—The widespread occurrence of fayalite in certain igneous rocks of Wisconsin. (20 minutes.)

THOMAS LEONARD WATSON—Structural relations of the granites of North Carolina. (30 minutes.) By title.

U. S. GRANT—Field work in the Wisconsin lead and zinc district. (10 minutes.)

A. R. CROOK—Molybdenite at Crown Point, Wash. (15 minutes, lantern views.)

PHYSIOGRAPHICAL.

C. F. MARBUT—Recent studies in the physiography of the Ozark region in Missouri. (10 minutes.)

W. M. DAVIS and E. HUNTINGTON—The physiography and glaciation of the western Tian Shan mountains, Turkestan. (25 minutes.)

HISTORICAL.

E. R. BUCKLEY—A system of keeping the records of a state geologic survey. (20 minutes.)

PHYSICAL AND STRUCTURAL.

WILLIAM HERBERT HOBBS—The tectonic geography of southwestern New England and southeastern New York. (45 minutes, lantern views.)

WILLIAM HERBERT HOBBS—The lineaments of the eastern United States. (45 minutes, lantern views.)

U. S. GRANT and H. F. BAIN—A pre-glacial peneplain in the driftless area. (15 minutes.)

E. O. HOVEY—Some striking erosion phenomena observed on the islands of St. Vincent and Martinique in 1903.

E. O. HOVEY—The new cone of Mont Pelé and other new features of the mountain.

E. O. HOVEY—The Grand Soufrière of Guadaloupe.

G. K. GILBERT—Domes and dome structure in the high Sierra. (30 minutes, lantern views.)

ALFRED W. G. WILSON—The Trent river system and the St. Lawrence outlet. (Read by title.)

FRANK BURSLEY TAYLOR—Postglacial changes of attitude in the Italian and Swiss lakes. (Read by title.)

GEORGE L. COLLIE—The basin of the Po river. (Read by title.)

F. P. GULLIVER—Nantucket shorelines, II. (20 minutes, lantern views.) By title.

HERMAN L. FAIRCHILD—The new geology under the new hypothesis of earth origin. (50 minutes.)

G. D. LOUDERBACK—The Humboldt region; a study in Basin Range structure. (15 minutes.)

GLACIAL.

M. R. CAMPBELL—Glacial erosion in the Finger Lake region, New York. (Read by title.)

H. L. FAIRCHILD—Evidences of slight glacial erosion in western New York. (20 minutes, lantern views.)

H. L. FAIRC ILD—Waning of the glaciers of the Alps. (20 minutes, lantern views.)

STRATIGRAPHICAL.

J. J. STEVENSON—The Carboniferous of the Appalachian Basin. Part II, the Pottsville. (Read by title.)

DAVID WHITE—Notes on the deposition of the Appalachian Pottsville. (30 minutes.)

J. E. TODD—The Benton formation in eastern South Dakota. (20 minutes.)

C. F. MARBUT—Further studies of Ozark stratigraphy. (15 minutes.)

A. P. COLEMAN—The Iroquois beach in Ontario. (20 minutes.)

GEORGE FREDERICK WRIGHT—Evidence of the agency of water in the distribution of the loess in the Missouri valley. (20 minutes.)

B. SHIMEK—Freshwater shells in the loess. (20 minutes.)

N. H. DARTON—Comparison of the stratigraphy of Black Hills, Big Horn Mountains, and Rocky Mountain front range. (Read by title.)

FIG. 1. Stratification of the loess in a railroad cut at Plattsmouth, Neb., at a depth of eighty feet from the surface. (From a photograph by Dr. A. L. Child, Kansas City, Mo., U. S. G. S.)

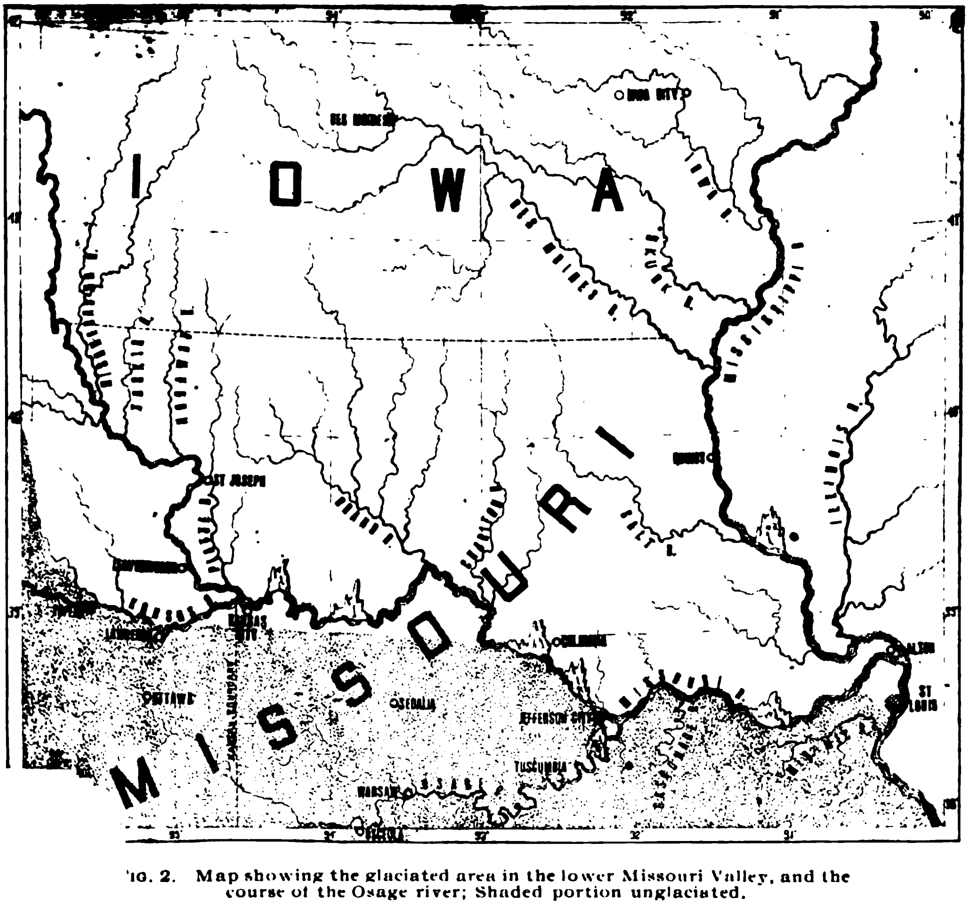

FIG. 2. Map showing the glaciated area in the lower Missouri Valley, and the course of the Osage river; Shaded portion unglaciated.

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EVIDENCE OF THE AGENCY OF WATER IN THE DISTRIBUTION OF THE LOESS IN THE MISSOURI VALLEY.

By G. FREDERICK WRIGHT, Oberlin, Ohio.

PLATES VII-VIII.

[Read at the late meeting of the Geological Society of America, St. Louis, Mo., Dec., 1903.]

In a series of papers, representing the results of wide observation and minute knowledge of the species of fossils found in the loess, professor B. Shimek* arrives at the conclusion that the loess of the Missouri and Mississippi valleys is largely an aeolian deposit; derived, indeed, from the sediment brought down by Glacial floods at various stages of the recession of the ice, but elevated to its present position through the agency of wind. The principal evidence in support of this theory is found (1) in the absence, in the deposit, of shells belonging to distinctively water species; and (2) the presence of land shells of species that live on the shores of ponds; (3) in the difficulty of imagining a submergence of the loess-covered area of such character as to account for its peculiarities; for in a permanently standing body of water the uniformity of distribution of material of the given degree of fineness characteristic of the loess could not be secured; (4) the reasonable influence of vegetation in arresting wind-blown dust. This was indeed an ingenious reversal of a former opinion. It had formerly been

*"A Theory of the Loess," *Proc. Iowa Acad. of Sci.*, vol. iii, 82-90, 1895; "Additional Observations on Surface Deposits in Iowa," vol. iv, 68-81, 1897; "The Distribution of Loess Fossils," vol. v. 98-113, 1898; "The Distribution of Forest Trees in Iowa," vol. vii, 47-59, 1899; "The Loess of Natchez, Miss.," AM. GEOL., vol. xxx, 279-299, 1902; "The Loess and the Lansing Man," AM. GEOL. vol. xxxii, 353-369, 1903; "The Distribution of Loess Fossils," *Jour of Geol.*, vol. vii, pp. 122-140, 1899.

supposed that trees and grass grew on deposits of loess, because such deposits furnished favorable conditions. It is now maintained that the loess accumulates where trees and grass grow, because it is there readily lodged and protected.

So strong is this evidence that nearly, if not quite, all of the Iowa geologists accept the theory.* But, on the other hand, there are so many facts looking in a contrary direction, that those familiar with them could not well rest in the simple hypothesis of the aeolian origin of the deposits. Prominent among these facts is (1) the distribution of the loess in about equal proportions upon both sides of the Missouri river. At Omaha the bluffs of loess on the west side of the river are scarcely, if any, less in dimensions than those of Council Bluffs upon the east side. In both cases a depth of one hundred feet is not infrequent. Farther down the river the deposits at St. Joseph, Mo., upon the east side, are indeed excessive, but this is readily accounted for by the direction of the currents of the river, and by the concentration at that point of the sediment brought down from Iowa by various streams, whose headwaters were near the border of the Iowan ice; the Nishnabotna, the Tarkio, and the Nodaway being noteworthy contributors of material to the valley above St. Joseph; while the Platte and the Missouri approach each other to within a few miles at St. Joseph. But at Leavenworth, upon the western side of the river, and at Kansas City, upon the southwestern side, the deposits of loess are also on a very extensive scale.

As the prevailing wind in this region is from the southwest, it would be hardly possible for it to pile up such deposits of loess upon the west side of the river, and especially upon the southwest side, as at Kansas City.

Secondly, the exclusive dependence upon wind for the distribution of the loess finds it difficult to account for the extensive level-topped terraces which frequently occur. At Omaha there is such a terrace in the upper part of the city about 150 feet above the present river level. At St. Joseph the deposit is much eroded by small streams, but the general level of many summits, at about 200 feet above the river, is in striking contrast to the surrounding higher land; while at Leavenworth a

*J. A. Udden, "Report on Mills and Fremont Counties." *Ia. Geol. Sur.*, vol. xiii. p. 174. 1902; T. E. Savage, "Geology of Tama County," p. 242.

very distinct level-topped terrace, more than a mile in width, and completely enveloped in loess, extends for three or four miles along the river, being bordered by the higher land rising abruptly about 150 feet above it. The level of this terrace is 150 feet above the river.

Professor Todd* extends this list of terraces of loess down to the mouth of the Osage river. At Kansas City they are prominent at an elevation of from 125 to 150 feet above the river, and lower down at Camden and Lexington, and especially in a flat surface covering several square miles in the great bend of the river in Saline county, near Marshall. Similar terraces are prominent, also, in Boone, Cooper, and Moniteau counties; the first being upon the north side of the Missouri valley, and the last two upon the south side. The depth of the loess upon these terraces is from 50 to 100 feet. Corresponding terraces appear on the tributary streams coming in from the north, especially along Grand river, east of Thompson's fork, near Chilicothe. Professor Todd also notes that "the loess and loamy clay present over most of its surface certain areas which are very level, to which the term 'flats' may be conveniently applied. On the other hand, the surface of the older formations, with its covering of residuary clay, very rarely shows such features, but is everywhere of rounded or broken outline. In applying this difference of character it should be remembered that there are not included the flat surfaces which are surrounded by higher levels, for such of course may be the result of recent alluvial deposition. The 'flats' of the typical loess region uniformly occupy the highest levels" (p 131).

It is extremely difficult, if not impossible, to conceive of the origin of such level-topped areas and terraces of loess, especially those on the west and south sides of the river, as due to wind deposits.

Thirdly, the agency of water in the distribution of loess is favored by, or at any rate consistent with, the facts that the loess is quite uniformly found to be thickest on the margin of the streams flowing out of the glaciated region, and that it is of somewhat coarser texture nearer the streams, thinning out at a distance from them, and merging gradually into a more

*Mo. Geol. Sur., vol. x, pp. 131-156, 1896.

clayey deposit. These facts are noted by nearly all observers, especially Chamberlin,* Salisbury,† Todd,‡ Upham,¶ and professor Shimek himself.|| I could add much from my own observations. It is sufficient, however, to refer to one locality only. In Kansas the ice extended only to the Kansas river from Topeka to its junction with the Missouri river. I have been over with some care the watershed between the Kansas river and the Descygnes, an upper branch of the Osage river running nearly parallel with the Kansas and 25 or 30 miles south of it. But upon this watershed, and in the valley of the Descygnes, there are no deposits of typical loess. The superficial deposits are entirely residuary clays.

Chamberlin and Salisbury speak as follows:—

"We find the loess in the vicinity of the Mississippi river (and the same is true of that near the Missouri, Platte, and other great rivers) of coarser grain than at points removed from it. In the river bluffs it sometimes merges into and becomes interstratified with layers that are a fine sand rather than a loess, some of them being typical sands serviceable for mortar. On the other hand, as the formation is traced towards its limit in the driftless region, it approaches more and more closely in character the residuary clays, seeming to be a mixture of true loess silt of foreign derivation and a varying percentage of local residuary earth."

Professor Shimek's effort to account for this by the action of wind to the exclusion of water is not altogether successful. His theory is that the material was originally brought down by streams from the glaciated region, and spread out over the broad flood-plains, where the winds had access to it, and, lifting it up, transported it into the interior; the stronger gusts occasionally moving sand upon the lower hights of the margins of the valley; while naturally the finer particles would be carried farther on than the coarser particles would be. While this would seem partially to account for the facts, it is no more successful in doing so than is a certain theory of water deposition, and notably fails to account for numerous facts mentioned in

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*Preliminary Paper on the Driftless Area of the Upper Mississippi Valley, by T. C. CHAMBERLIN and R. D. SALISBURY, *Sixth An. Rep., U. S. Geol. Sur*, p. 281.
†*Ark. Geol. Sur.*, vol. ii, 1899, Report on Crowley's Ridge, p. 226.
‡*Mo. Geol. Sur.*, vol. x, p. 128, 1896.
¶*Ninth An. Rep., Minn. Geol. Sur.*, p. 307.
||AM. GEOL., vol. xxxii, p. 366, 1903.

Miss Owen's paper concerning the composition and stratification of the loess at St. Joseph, and the similar facts of massive stratification to which professor Winchell has called attention.* A typical illustration of the stratification in the loess is shown in the accompanying photograph, taken by Dr. A. L. Child in a railway cut at Plattsmouth, Neb., at a depth of eighty feet from the surface.

In reference to this whole question of the deposition of the loess it should be observed that, as professors Chamberlain and Salisbury have clearly demonstrated, "Typical loess is neither a sand nor a clay, but a silt of intermediate fineness. It is finer and more uniform than sand and less fine than clays and residuary earths, though the latter are generally less homogeneous and their constituents have a wider range in size. The loess is conspicuously coarser than the residuary earths, if we may judge from the fact that, after the particles of the latter have been thoroughly separated from one another and the ultimate physical elements caused to be freely suspended in water, a much longer time is required for the settling of the particles than is the case with loess when subjected to the same treatment."†

Professor Shimek endeavors to support his aeolian hypothesis from facts which he has observed at Council Bluffs and some other places showing that "the loess is usually of approximately uniform thickness on tops and slopes of hills, and is often laminated parallel to the surface;" and asks, "Under what conditions could flooded streams have produced these results?"‡ The answer will readily be found in a brief consideration of the conditions connected with these temporary floods which may be supposed. The outlying country upon either side of the Missouri valley, under the influence of long-continued subaerial agencies had been rendered rough and irregular in outline, so that, while the water outside of the channel of the river was in a static condition during floods, the loess would settle down over the surface like a blanket in uniform thickness, leaving the irregularities to a great extent as pronounced as before. Cer-

*"Was Man in America in the Glacial Period," *Bull. Geol. Soc.*, vol xiv, p. 143, 1903.

†Preliminary Paper on the Driftless Area of the Upper Mississippi Valley, by T. C. CHAMBERLIN and R. D. SALISBURY, *U. S. Geol. Sur., Sixth An. Rep.*, p. 278, 1884-85.

‡"Loess and the Lansing Man," AM. GEOL., vol. xxxii, p. 336, 1903.

tainly it is as easy to conceive of the deposit's taking place in this way as of its being left by the wind in the manner supposed. The extensive level areas of loess referred to probably accumulated over rock shelves or expanses which were already approximately level.

Such being the case, it could represent a deposition either from moving water or moving air of given velocities upon a diminution of the currents. As I have elsewhere maintained,* there can be no question that large bodies of typical loess in eastern Mongolia and northern China are wind deposits. In numerous places over those regions typical loess is drifted in on the lee side of the mountain 5000 feet high as snow is drifted on the lee side of fences; so that, in accounting for the ultimate origin of the Chinese loess, I could see no better explanation than that of Richthofen, that it has been brought in from the arid regions of central Mongolia by the strong prevailing westerly winds, and accumulated along the mountainous border which marks the boundary between Mongolia and China proper. From these centers of accumulation it is now in process of rapid erosion, being carried by the streams to lower levels along the coast of China. In similar manner it may be plausibly maintained that the ultimate origin of the loess of the Mississippi valley may be found in the arid plains west of the Missouri over which winds of a definite velocity have been sweeping the material eastward during long pre-Glacial times, permitting it to accumulate over the area subsequently covered by ice. But that it was immediately distributed into its present position largely by ice and the floods of water ensuing upon its departure can now be maintained with greater confidence than formerly by reason of a remarkable discovery announced by professor Buckley, of the Missouri Geological Survey, at the meeting of the Geological Society of America at Washington, in January, 1903. This announcement was that granite boulders of considerable size had been found as far south as Tuscumbia. This startling announcement really opens up a new chapter in the Glacial history of this region, and prepares the way for a very satisfactory explanation of the loess deposits in the valley of the Missouri above the Osage; for the

*"Origin and Distribution of the Loess in Northern China and Central Asia," *Bull. Geol. Soc. of Am.*, vol. xiii, p. 138, 1902.

explanation of the deposition of these boulders brings into positive view movements of water in the Missouri valley just such as are needed to account for the main deposition of the loess.

Tuscumbia is situated in the trough of the Osage river sixty miles above its mouth, and fully forty miles south of the limit reached by the ice of the Glacial epoch. The Osage river occupies a very old line of drainage with a diversified history. It runs across the lower flanks of the Ozarkian uplift, in a line nearly parallel with the Missouri and Kansas rivers, having lowered its channel nearly as fast as the Ozarkian elevation proceeded; so that now it is about 300 feet below the general level on either side. The edges of the upper part of the valley are several miles apart, while the immediate trough is about one-half mile wide, with perpendicular bluffs of magnesian limestone rising from 50 to 100 feet above it.

Cross section of the Osage trough at Tuscumbia showing the position of a boulder on the Sedimentary Terrace.

The space between the rocky bluffs is occupied by the river with its flood-plain and a bordering terrace from fifteen to twenty feet above high-water mark, which furnishes an excellent strip of arable soil. At eight localities along this inner gorge extending from four miles above Tuscumbia to several miles below, professor Buckley announced that Dr. Ball, in the survey of Miller county, had found granite boulders. The upper two of these I have visited. The first of them, on Mr. William A. Barron's farm, four miles up the river from Tuscumbia, lies buried in the bordering sedimentary terrace, so that just the top of it is visible. It is about 100 yards back from the river, and about 300 yards from the rocky bluff upon the west side. The boulder measures 4×3 feet upon the surface, and is buried as much as two feet under ground. How much more could not be ascertained with the means at my disposal. It is a compact, close-grained gray granite, gneissoid in its structure, and would probably weigh several tons. The other boulder which I examined was upon the farm of Mr. John Weitz, one-half mile back from the immediate trough of the river in a broad opening made in the bluff by Shut-in creek. Its elevation is from fifty to sixty feet above high-water mark in the river. This was of smaller size, and would weigh about one-half a ton. In character it is much like the other, but more distinctly gneissoid in its appearance.

The other boulders reported are similarly situated with reference to the valley, being in the trough of the river. But it is worth noting that several of them are of different varieties of granite, some of which Dr. Robert Bell recognizes as of Canadian origin.

To account for these boulders in this relation there are only four hypotheses possible:—

1. That they are from outcrops of granite in the Osage valley. But no such outcrops are known, and the ground has been so thoroughly explored by members of the State survey and by others that the negative evidence is complete. They cannot be of local origin.

2. That ice extended to this point forty miles farther south than had formerly been supposed. But this supposition is untenable in view of the carefulness with which the border has been examined by a number of geologists. After careful search by various members of the Missouri survey and others, no signs of glaciation have been found within forty miles of this locality. To satisfy myself upon this point I was at the pains of surveying the country along the new line of the Rock Island R. R. running from St. Louis to Kansas City, and keeping from thirty to forty miles south of the lower part of the Missouri river, crossing the Osage forty-five miles above its mouth, or fifteen below Tuscumbia. I have also taken a section northwest from Tuscumbia forty miles to California, and a smaller one from Bagnall to Jefferson City.

Of course the failure to find any glacial phenomena over this border south of the Missouri is negative evidence, but it is so extensive as to be practically conclusive. Besides, it is in the highest degree improbable that there should be so many large boulders in the limited area of the river valley about Tuscumbia without its being due to some special cause. There is no reason why, in the ordinary advance of an ice sheet, such boulders should be accumulated as they were in the Osage valley.

Furthermore, it is clear, from the position of these boulders, that they do not belong to the Kansan epoch of the glacial period. The sedimentary terrace upon which some of them are situated very clearly belongs to a late period in the order of glacial events.

3. A third possibility is that the Kansan ice-sheet had advanced beyond Topeka so as to extend over the watershed between the Kansas and the Descygnes river, or perhaps that there had been a channel of overflow from a temporary Glacial lake in that region; so that ice floes bearing these boulders were carried into the head-waters of the Osage, and floated down 200 miles or more to their present position. But of such advance of the ice across the Kansas river there is no evidence; while everything bears in the strongest manner against the supposition, though there are some rather indefinite reports of Glacial overwash south of the Kansas river basin.

It was reported to me, for example, that south of Kansas City, at Pleasant Hill, on one of the small tributaries coming into the Osage, a few granitic pebbles had been found. It had been reported, also, to professor Haworth that a rounded granitic pebble several inches in diameter had been found in Coffey county, 50 or 60 miles south of Topeka. This would be in the drainage of the Arkansas river. A personal examination, however, of the watershed between the Kansas and the Osage river in the most likely place for an overflow, 20 miles south of Lawrence, as well as of the deposits in the Osage river from Ottawa to Osawatomie, and on its northern branch at Paoli, demonstrated to my own mind about as well as negative *evidence* can, that there had been no extensive overflow from the Kansan extension of the ice-sheet into the headwaters of the Osage river.

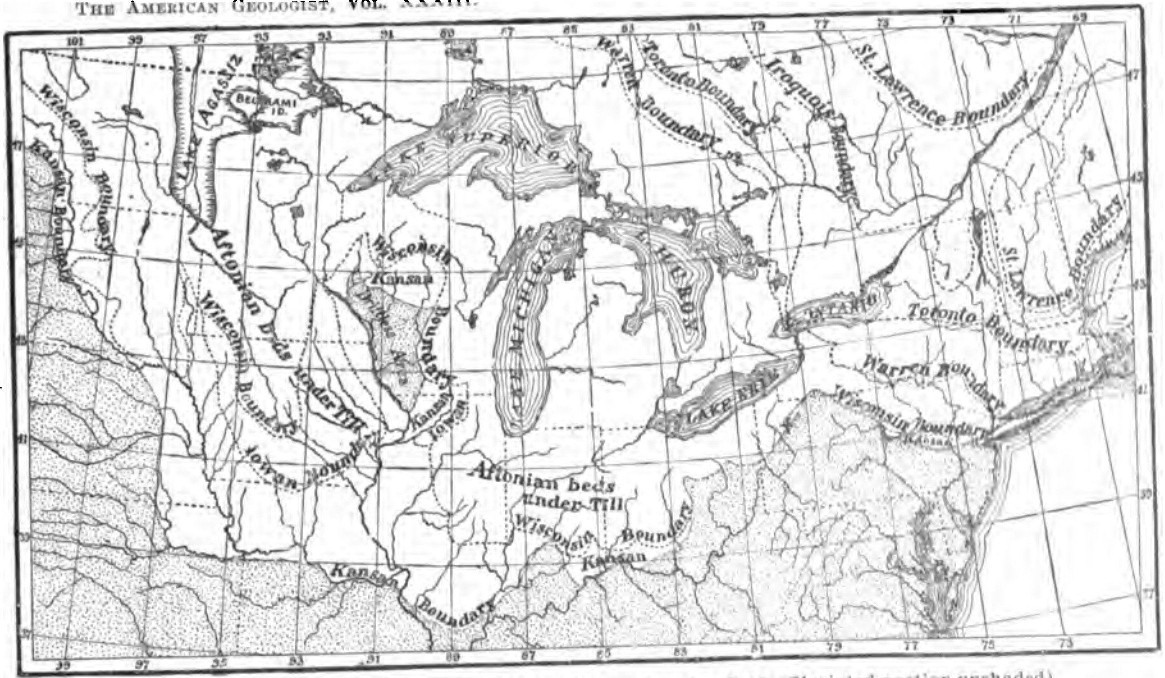
4. We are therefore limited to the fourth hypothesis, namely, that the boulders at Tuscumbia were transported upon ice floes 64 miles up the Osage river by back water produced when the Missouri was subject, in the closing stages of the Glacial period, to annual floods of great extent from causes which did not affect its southern tributaries. The existence of such favor-

ing conditions is readily brought to light by a study of the causes kown to have been in operation. Stated comprehensively, these are: (1) the rapid melting of the ice over a large area tributary to the Missouri river, thus furnishing an ample supply of water; (2) the absence of any corresponding increase in the water supplied to the Osage river, which lies entirely outside of the glaciated region; (3) a probable, or at any rate, possible, diminution of the grandient of the Missouri river by reason of a differential depression of the land towards the north; (4) a reduction of the gradient of the Missouri river by reason of corresponding high water in the Mississippi; (5) the narrowness of the gorge of the Missouri below the Osage river, which would cause an abnormal rise of water above that point for a brief period each year.

(1) At the present time it is estimated by Humphreys and Abbott,* that the Missouri river annually discharges about 28 cubic miles of water, which is but 15 per cent of the total rainfall. Letting this stand as a constant quantity, we can readily see that the entire amount of water furnished by the melting of the ice during the closing stages of the Glacial period would have to be added to this amount. since the evaporation is as much now as it ever was. Bearing upon the supply of water this furnishes professor Todd supplies the following facts and estimates:

"Vast quantities of water were available for the purpose of depositing the loess. The amount may be estimated as follows: At the time of the first or Altamont moraine the Missouri received the melting from 130,800 square miles of ice sheet in the United States, that is one-half of Dakota, one-third of Minnesota and one-sixth of Iowa, besides there was probably as great an area in Canada to be added, because the upper Saskatchewan at that time doubtless drained into the Missouri river. The ablation of certain Alpine glaciers as estimated by Desor is ten feet a year, by Forbes over twenty feet, and even as high as two and one-half inches a day has been observed. It seems not unreasonable to count most of this area in the zone of ablation at as much as ten feet for the United States alone,

*Report on the Physics and Hydraulics of the Mississippi River, by CAPT. A. A. HUMPHREYS and LIEUT. H. L. ABBOTT, Professional Papers of the Corps of Engineers, *U. S. Army*, No. 13 (1861); reprinted with additions in 1876, p. 84.



Map showing stages in the recession of the North American ice-sheet, (Glaciated portion unshaded) and the vast areas of melting ice draining into the Missouri and Mississippi valleys.

or five feet, to be very liberal, for the United States and British America. Supposing the area of the latter to equal the former, there would then be 250 cubic miles of water a year or ten times the amount now discharged by the Missouri river. In this no account is taken of the water drained from the rest of the basin which was certainly no less than now. If counting the extension into Canada by the Saskatchewan as equal to the area occupied by the ice it may be put down as a moderate calculation that the river discharged eleven times as much water as at the present time, with the probability that it discharged at least for certain years twenty times as much."*

Professor J. D. Dana† had made similar calculations concerning the supply of water from the melting ice in the valley of the Connecticut river as I had also done at an earlier date concerning that in the upper portion of the Delaware valley.‡ Professor Dana calls attention to the aid which would be given in melting the ice in the last stages of the Glacial period through the existence of crevasses of great extent and of surface and subglacial streams of water, producing open channels and tunnels, which would greatly add to the exposed surfaces. He also supposes that the presence of the ice would greatly increase the precipitation, so that the supply of water would be greatly enlarged from that source as well as from the melting of the ice. Altogether he thinks it not improbable that 460 cubic miles of water were for a short period annually set free by the melting of the ice over an area of only about 8,000 square miles.*

Professor St. John has favored me with more detailed calculations, as follows:—

"The quantity of heat received during a year by the region of the earth lying between latitudes 41° and 50° N. may be found approximately. Assuming the solar constant to be 30 calories per square meter, the heat from the sun falling vertically upon an equatorical section of the earth would be sufficient to melt a layer of ice about 700 feet thick in a year. The quantity of heat per unit area varies with the sine of the sun's

*"The Formation of the Quaternary Deposits in Missouri, *Mo. Geol. Sur.*, vol. x, pp. 114-217, 1896.

†"The Flood of the Connecticut Valley from the Melting of the Quaternary Glacier," *Am. Jour. Sci.*, vol. xxiii, pp. 87-97, 179-202, 360-378, 1882.

‡"An Attempt to Estimate the Age of the Palæolithic-bearing Gravels in Trenton, N. J.," *Proc. Boston Soc. Nat. Hist.*, vol. xxi, pp. 137-145, 1881.

altitude. The mean sine of the altitude of the sun in latitude 45° 30′ N. the middle of the zone under consideration from the vernal to the autumnal equinox is approximately 0.919 and from the autumnal equinox to the vernal equinox it is approximately 0.492. The heat incident upon a plane perpendicular to the sun's rays is sufficient to melt a layer of ice 1.92 feet thick per day. Upon a plane over which the mean sine of the sun's altitude is 0.919, the amount of heat energy received in the 186 days from the vernal equinox to the autumnal equinox would be sufficient to melt a layer of ice 328 feet thick (1.92 x 186 x 0.919 = 328). Similarly for the plane over which the mean sine of the sun's altitude is 0.492, the quantity of energy in the form of heat received in 179 days from the autumnal equinox to the vernal equinox would be sufficient to melt a layer of ice or snow 168 feet thick (1.92 x 179 x 0.492 = 168). If this heat were uniformly distributed over the zone of the earth's surface lying between latitudes 41° and 50° N. it would be sufficient in amount to melt layers of ice approximately 80 feet and 41 feet respectively. Assuming that the rate at which heat is received from the autumnal equinox to the vernal equinox is sufficient to keep the temperature up to the melting-point, the heat received in excess of that during the period from the vernal to the autumnal equinox might be taken as an approximate measure of the layer of ice melted during that period of the year, i.e. it would be sufficient to melt a layer 39 feet thick (80 — 41 = 39). This would still have to be decreased for the atmospheric absorption, for the loss by radiation, and for the low absorbing power of the ice surface; so that the actual melting would be much less than the thickness given above."

But if we assume that the melting proceeded at one-third this possible rate, we should then have at least 500 cubic miles of water set free in the middle Missouri valley each year between the vernal and autumnal equinoxes, all of which would have to pass through the constricted gorge in the lower part of the valley. Considering the decayed condition of the ice during the late stages of melting and the probable thin covering of accumulated dirt over large areas near the front, this rate would appear altogether probable. Supposing this gorge to be only two miles wide, as is really the case, and to be filled with water 200 feet deep, flowing at the rate of three miles an hour, 166 days would be required to discharge the total amount. But the progress of events would not be so simple as this. The waters would begin to rise soon after the vernal equinox, and continue so to do until the early part of August, when they would reach their maximum hight, and continue for a brief period of perhaps three or four weeks, when they would begin to subside, because of the diminishing supply, as the autumnal equinox approached.

To make as correct a calculation as possible upon the problem presented, I have submitted to professor Alfred C. Lane a hypothetical case making the supposition that 500 cubic miles of water were set free in the middle portion of the Missouri valley by the melting of the sun's rays between the vernal and the autumnal equinox while the outlet of the channel below the Osage river was restricted to a width of two miles and a depth of 200 feet, and at the same time obstructed by high water in the Mississippi river, what depression at the north would be required to reduce the gradient sufficiently to slacken the current to three miles an hour? In reply the following was received, which will shed much light upon the whole subject, and show that the movement of water which we have supposed is entirely within the range of mathematical probability.

Lansing, Mich., Feb. 13, 1904

My dear Mr. Wright:

In reply to your inquiry as to flow and discharge of the glacially flooded Missouri or Mississippi I should use Sullivan's formula $V = K R^{3/4} S^{1/2}$, when V is the mean velocity (not maximum velocity at the surface which will be from $^1/_3$ to $^1/_4$ more). In a stream 2 miles broad or so and only about 200 feet deep R, which is the area of the stream divided by the wetted perimeter, will be within 2% or 3% the same as the depth (d) and we may write $R^{3/4} = d \div \sqrt[4]{d}$. The fourth root of d will vary quite slowly. For d = 200 it will be 3.76. K depends upon the roughness of the stream bed and varies from 19 to 75, being 38.40 for the Mississippi at Vicksburg and 36.48 for it at Columbus, Ky., and 37.50 for the Rhine. If we take its value for convenience at 37.6 we shall have, mean velocity = 10 (depth = 200) $\sqrt[2]{S}$. Three miles an hour would mean 4.4 feet per second, $4.4 = 2000\ ^2\sqrt{S}$. $S = (.0022)^2 = .0000048 = .0253$ feet per mile. This is considerably less than the slope of the Mississippi at present. The amount delivered in a day would be the velocity times the area $= 3 \times 24$ ($= 72$ miles per day) $\times$ 2 (miles broad) $\times$ ($^{200}/_{5280}$) miles deep $=$ 5.3 cubic miles per day. It would take some 96 days to carry off the amount of 500 cubic miles of water which you mention.

We may write the formula, discharge $= K \times$ width $\times$ depth$^{7/4} \times$ slope$^{1/2}$, and it is apparent that the discharge will vary pretty nearly as the square of the depth or the square root of the slope, being much more sensitive to changes in depth than to changes in slope. I may say that K is less, the rougher the channel is, and I should imagine that in a flood it would be less rather than more than 37.6, and the velocity and discharge for a given slope less. Moreover you will remember that the expression for the slope applies only so long as the section is of the shape you mention, and for the same discharge and depth but greater width the slope will drop rapidly being inversely as the square of the width.

It is perfectly obvious that differential depressions only of the same order as the uplifts Gilbert finds to be now going on, might give flood sections of the breadth and depth you mention if the amount of water to be discharged were as great as you mention. If the discharge may be assumed to vary from the spring to the fall equinox in a simple harmonic ratio then the mean discharge would be $\frac{7}{11}$ ($\frac{2}{\pi}$) of the maximum. This, if the former is 5.3 cubic miles a day, $\times$ 182 days ($= \frac{1}{2}$ year) would be about 620 cubic miles per annum. But it is probable that the exceptional flood is in a greater ratio to the mean discharge than 7 : 11. For to take a random instance from the measurements of the U. S. Geological Survey Water Supply Paper No. 84, p. 19, the mean discharge of the Niobrara river at Valentine, Nebraska for March to August inclusive was 844 second feet, which at the ratio 7 : 11 would imply a maximum of 1330 second feet or according to their rating table 1.9 feet gage hight. Whereas they had a number of days a little above this, and one flood up to 2.05 feet.

Very truly yours,

ALFRED C. LANE, State Geologist.

This production of a temporary lake in the middle of the Missouri valley by the melting away of the ice to the north would produce all the conditions necessary to support the aqueous theory for the deposition of the loess. A difficulty in the theory of a permanent standing body of water is that the sedimentary material brought into such a lake would be precipitated not generally throughout the area as it is, but in something like deltas upon the northern border; but, under the present supposition, we have a constant movement of water along the main line of the Missouri such as Miss Owen all along insisted was necessary to furnish a supply of material as far down as St. Joseph, Kansas City, and points still farther below. In the main current of the stream, therefore, the material of the fineness of the loess would be continually kept in motion, so that there would be no need of supposing the bed of the river to silt up to any great extent, except in the northern portions, where the coarser gravel and sand would be deposited, as we find is the case. But upon the border of the main current, the water charged with sediment would constantly be spreading over, and losing its motion, so as to deposit its material after the analogy of an ordinary river overflow.

On the supposition that these conditions actually occurred, practically all the objections to the aqueous theory are removed, for it is well known that aquatic shells are not found on the flood-plains of rivers; on the contrary, such localities are favorite places of land snails. In the conditions supposed, the submergence of the higher elevations, where, for the most part, shells are found in the loess, would not occur until the later part of the summer, and would continue but a short period. In such case there would be ample opportunities for the development of land species of snails and no fit conditions for aquatic species.

If it is objected that these shells indicate a climate about such as now characterizes the region, it is to be observed that such it probably was during the closing stages of the Glacial period. A warm climate was required to melt the border of the ice, and the ice-covered region was at this stage 100 miles or more to the north.

The actual existence of such a periodical rise of the Missouri river as we have supposed is directly proved by the position of the Tuscumbia boulders, where, as already remarked, it is easily perceived that the Osage river, flowing entirely outside of the glaciated region, would not be subject to any abnormal rise of its waters from causes operating in the upper part of its basin. On the other hand, as the water in the Missouri rose an actual current of backwater would set up into the Osage valley, which might easily carry ice floes loaded with boulders which had been brought down from the glacial tributaries of the Missouri, while such an upward current is absolutely necessary to get them into the positions where they are found. The one in Shut-in creek especially was not far from 150 feet above the present level of the Missouri, which would involve a rise of about 200 feet in the Missouri to accomplish the result.

Phenomena analogous to this are too familiar to need specification. My own attention, however, to such a movement of water up a tributary stream was early attracted by an occurrence upon Hubbardton creek, in Westhaven, Vt. This creek flows from the north into the lower portion of Poultney river, or East bay, as it was called, near where it enters the head of lake Champlain. At one time a series of terrific thunder showers passing over the headwaters of Poultney river raised the stream in its lower portions to a great hight, while there was no corresponding rise in Hubbardton creek. As a result, a milldam in the lower part of the creek was bodily carried upstream by the back water which set in from East bay. A similar current of back water annually sets up the Williamette river in Oregon, upon the rise in the Columbia, due to the melting snows about its headwaters.

This positive evidence of such a rise in the Missouri river is sufficient of itself to compel us to imagine conditions which would bring it about. In doing this we are aided by

(3) The probable diminution of the gradient of the Missouri river by reason of a differential depression of the land towards the north. This is a phenomenon so generally witnessed to over the northern portion of the glaciated area that it needs no further reference. Such a differential northern depression is not only possible, but is altogether probable in accordance with the analogy of a great number of known facts relating to the region. But we are aided also

(4) By the supposition of a reduction of the gradient of the Missouri river by reason of corresponding high water in the Mississippi; for, at the time of the discharge of these immense volumes of water into the valley of the Missouri, there was an equal, if not greater discharge, into the Mississippi valley proper. Whatever rise would occur in the Mississippi would tend to lower the gradient of the Missouri to that amount.

In considering this matter of the gradient of streams at flood time, it is to be remembered that a rise of a given amount in the upper portion of the stream is distributed over a long distance in its outflow. At the time of the remarkable flood in the Missouri river on the 8th of June, 1903, I was at St. Louis, when the water in the Mississippi had risen to a hight of 37 feet and was overflowing the flood-plain for a width of about five miles, and in some places of ten miles. The announcement of the Weather Bureau led us to expect that the flood would begin to subside on that day, but four days after, upon the 11th, the water, instead of subsiding, had risen another foot, making 38 feet, though there had been no rain in the meantime. The truth was that the supply of water from a limited area in the valley of the Kansas river had been such as to produce a lake in the Missouri valley several hundred miles long, and from five to ten miles wide, furnishing a mass of water whose movements baffled the calculations of the Weather Bureau. At Kansas City, the Kansas river, which brought in the larger amount of the waters of the flood, pushed out such a strong current into the Missouri valley that it carried railroad cars completely across the main current of the Missouri, and landed them upon the other side of the valley. This current of the Kansas river across the Missouri acted like a dam, producing slack water in the Missouri for many miles above.

(5) Finally, the Missouri river for a distance of more than 100 miles both above and below the mouth of the Osage river flows in a gorge 300 feet deep, and less than three miles wide; while at Hermann, 25 or 30 miles below the mouth of the Osage river, it is barely two miles in width between the upper rock bluffs, and would average at this point considerably less. We have, therefore, all conditions necessary for the production of such variations in the water levels of the middle Missouri val-

ley as are needed to account for the deposition of the Tuscumbia boulders, and for most of the complicated facts connected with the loess of the region.

As the loess does not extend up the Osage valley as far as Tuscumbia, this may be urged as an objection to the theory here maintained. But a little reflection will show that it is not a fatal objection. The current of water setting up such a side tributary would necessarily be limited each season to a single filling of the channel with silt-laden water, while most of the silt would be deposited near the mouth where it entered. Very little silt would remain in suspension when the slow-moving current had reached so distant a point in the *cul de sac*.

An additional irresistible inference from the facts is that not only were the Tuscumbia boulders floated into their place during the later stages of the Glacial period, but that this occurred not a great many thousand years ago, and so furnishes an additional argument in support of other calculations which bring the closing stages of the Glacial period down to within the limits of about 8,000 or 10,000 years; for, as has already been said, the large granite boulder on Mr. Barron's farm lies upon the top of a sedimentary terrace barely 20 feet above the present high-water mark of the river, and about one-third of the way, or 300 feet, between the present bank of the river and the rocky bluff upon the west side. This sedimentary terrace is now in process of degradation. The river is striking against it, now upon this and now upon that side of the valley. The small amount of work already accomplished in its degradation is clear proof that it has not been at work for an indefinite period of time, but at the outside for only some such period as is indicated by the shorter chronological calculation for the close of the Glacial period.

THE LOESS AT ST. JOSEPH.

By Miss Luella A. Owen, St. Joseph, Mo.

PLATES IX—X.

[Read at the late meeting of the American Association for the Advancement of Science, at St. Louis, Jan., 1904.]

The numerous cuts, at various elevations, in the loess at St. Joseph, Mo., offer unusual facilities for observations on that formation and study of the methods of its deposition. As is well known the river channel at that point is deep and narrow, the valley correspondingly so as compared with its width at other places, and the loess mantle exceptionally thick. The underlying rock ledges are not so pronounced and never so continuous as at many familiar portions of the bluffs; and this condition, having encouraged much freedom in the establishing of street grades, has resulted in the exposure of numerous surfaces whose undisturbed condition admits no doubt. Neither are they subject to discussion as to recent alteration by wash or slip for the reason that the most important cuts referred to are in the main mass of the bluff and not at the edge of doubtful slopes nor in the fringe of disturbed borders. These exposures may therefore be accepted as typical and their testimony admitted in the effort to decide what "typical" loess is and by what agency it was deposited.

In referring to exposures of special interest it seems advisable to indicate the localities in order that those who wish to examine them hereafter may do so.

In the bluff section overlooking the river at the northwest of the town the cuts at different elevations show little variation in composition, texture or general appearance, excepting in the one quality which might be termed cohesive density, and which in the original deposit invariably diminishes with increase of altitude. The old cut known as "dug hill" was made something like forty years ago, yet its walls maintain their perpendicular with but slight effects of weathering. No stratification lines have been observed there and the difficulty of finding snail shells suggests that if the deposit is of aqueous origin it was laid in water too deep for the development of snail colonies. It is not the intention to claim that no fossils are to be found at low levels, but if the fossil-bearing deposit of the summit continues down a slope, maintaining the general upland appearance, character and thickness, no far-seeking is required for an explanation. The slope is an ancient one where summit conditions at some time prevailed and is often the termination of a spur at the outlet of a small valley or ravine where a tributary current has at all times kept an open gate-way through the bluff. Corresponding altitudes in a deep cut penetrating the bluff are either non-fossiliferous or the shells are small.

At St. Louis and Water streets, where the street level is 143 feet above extreme high water, a recent exposure presents the same homogeneous appearance, but the rains of two summers have eroded it in small furrows like perpendicular wrinkles and snail shells of the elongated spiral form are distributed throughout, the numbers increasing with the ascent as usual. If the depositing agency here were aeolian it would seem that the winds must have been strong and long continued, else we should recognize periods of interruption marked by a dark mixture of deep soil resulting from a rank growth of vegetation somewhat similar to present surfaces where accumulations exceed erosive loss. Only wiry plants grow in the drought of a dusty wind and they offer scant support to snails.

An example of the tenacious character of the loess is a conspicuous landmark at Fifth and Faraon streets where the remnant of a cut made in 1868 still maintains its perpendicular. The exposure is distinctly stratified above the street level of 106.5 feet above extreme high water, although the laminations are not marked by variations in color. This uniformity of color is also observed in the strata exposed at the site of the South St. Joseph water-tower at an elevation of 270 feet above extreme high water. Extreme high water indicates the stage reached by the flood of 1881 when the entire flood-plain, from bluff to bluff, was inundated and is 816 feet above the sea. The only greater altitude in the vicinity of St. Joseph is at the main water-works seven miles further north.

The necessary leveling for the construction of the tower left a perpendicular exposure of ten or more feet at the summit of the hill (plate X). The weathering of this shows horizontal strata with great distinctness, and snail shells ranging from the most minute to fully mature sizes are abundant. The two shapes common to the loess are represented, but the elongated spiral form is in much greater numbers than the flat circular species. At the top of this exposure there are about twelve inches of a mixed deposit of undoubted aeolian and vegetable origin which is without shells.

A similar exposure left by leveling for the electric light tower on the bluff north of Pacific street also shows high level strata rich in shells with the elongated spiral forms predominating. Portions of the laminae exposed here are slightly stained with iron, as are those at the base of the bluff shown in the cut at 14th and Hickory streets where the level is only 88. But the most striking of all is a deep new cut at a distance of three or four blocks to the southeast and at a much higher level. The cut reveals a ledge of decomposing shale and its accompanying bed of clay, capped and bordered by a thick mass of loess the main part of which is broadly banded with iron stain almost up to the short grass roots. The line of contact between the loess and underlying shale and clay is sharply distinct as in the tunnel at Lansing where the skeleton was found; but here the unbroken horizontal bands of iron stain prove that the underlying loess on the slope occupies its original position against the sloping clay and, therefore, is not the result of wash or slip nor a recent contribution transported by the wind.

In many places on the Asylum road, especially at points about two miles east from the river, the iron-stained laminations in the loess are exceptionally brilliant in hue. It is also noted that they undulate in regular and parallel ripples. Here and beyond there is a thinning out of the loess and in places the glacial till is exposed at the surface. Two large quartzyte boulders are prominently planted on a hill that slopes toward the road.

In late summer when the volume and current of the Missouri river are much reduced, the process of spreading a yellow stratum on an almost forsaken bar may often be observed; but there appears no satisfactory evidence or hypothesis by which the origin of horizontal iron-stained bands may be fixed by a high, dry wind. Assuming, however, that all known facts were in favor of aeolian origin of the loess, where could there have been river bars of sufficient extent to yield the supply for the deep mantle covering the region about St. Joseph? It is also safe to remember that during the long cold season, when floods were reduced, the land may have been buried under excessive falls of snow. Then, too, it might be asked by what law of nature did the winds confine their energy wholly to the flat, low-lying river bars while the higher and, supposedly, dryer mantle of till and beds of residual clay remained undisturbed to be gently, but deeply covered.

Objection to the glacial origin of the loess has received its most convincing support from the repeated declaration of the absence of any barrier at or below Kansas City to retain a body of water of the depth required for building the bluffs to their present hight. But such a barrier did exist and still remains. The point where the Missouri river bends at Kansas City is, and apparently always has been, a drainage basin with its only outlet towards the east. The water-shed tributary to the Missouri at that point attains altitudes above sea level ranging from 1000 to 1100 feet within a distance of sixty miles. That of the union depot at Kansas City is only 750. The floods pouring in here from the vast drainage area on the west must have been met and held in check by the waters from the north in the manner shown by the lesser floods of the present age during the high water period in May of 1903. (See plate IX.)

When the main current of the great flood was thus forced to change the direction of its flow the velocity must have been suddenly diminished to some degree, with the result of excessive precipitation of sediment at that point.

As has been shown by professor G. Frederick Wright, in "The Nation" of December 10th, 1903, this southern barrier continues eastward for a distance of about 300 miles, it being noted by him as the first beginnings of the Ozark uplift and the obvious cause of the abrupt eastward turn of the Missouri river. In the same article he has further shown that the narrowing of the gorge of the Missouri to two miles or less at a point below the mouth of the Osage necessarily forced the glacial floods to pass through at a rate so reduced as to compel an accumulation forming an extensive temporary lake of a depth sufficient to have covered any existing hights of the present bluffs.

Since these observed facts can be verified without difficulty they give to the aqueous theory a support that renders immaterial the contested supposition of whether or not the region

has ever been subject to alternate periods of elevation and depression.

An objection advanced in opposition to aqueous deposition of loess is that a current flowing at the rate of even three or four miles per hour would carry a large quantity of coarse material which the bluffs do not contain. Although this objection appeals to reason it is not supported by the Missouri river. At St. Joseph the average normal rate is seven miles per hour, *at the surface,* yet the finest sand required for building purposes is taken from the channel, the coarse material having been lost in more shallow water.

In view of a reasonable interpretation of observed facts the next question suggested is whether the snail shells are to be taken as evidence of the origin of the loess or if the loess is to be used for testimony in throwing light on the character and habits of its imbedded snails. It may not be impossible that snails have been forced to gradual changes of habit during the varying conditions of centuries comparable to those of the ostrich since its ancestors were Cretaceous water-fowl.

In The American Geologist for December, professor Shimek asserts with much positiveness that, "There is not a single well authenticated species of fluviatile mollusks known from clearly undisturbed loess in this country." Such a statement leaves no doubt as to personal conviction, but carries no proof of its correctness, so it may still be asked if the loess fossils can be positively identified.

On the subject of identification of snails Theodore Gill, supporting his conclusions by those of professor Huxley, says, "The same kind of shell may be common to forms that are radically different in their organization, and there is no *a priori* reason why the modifications of the shell should be of any greater value than those of any other single part of the organism. We should in all cases allow ourselves to be guided by the consideration of the sum-total of characteristics." And continuing, "It is thus seen that the form of the shell, and even the presence or absence of a shell, are of very inferior systematic significance, and entirely subordinate to differences in structure of the animal."

If this is true we are at liberty to assume that the loess fossils from the water-tower hill, identified for professor Winchell by professor Shimek as Polygyra multilineata, Pyramidula alternata, and Succinea obliqua, may with equal certainty be referred to the genera Planorbis and Limnea of the family Limnæidæ, and Paludina integra of the family Paludinidæ. The aeolian theory would accordingly suffer the loss of its best support.

ON THE CLASSIFICATION OF SEDIMENTARY ROCKS

By Amadeus W. Grabau, New York.*

All true classifications are based on development or the genesis of species. A species, however, in the only correct sense of the word, is monophyletic; i.e., individuals of the same species can not develop independently from two ancestors in the same or distinct regions unless these ancestors also belong to the same species; i.e., have a common ancestor. In the inorganic kingdom, species (in the biologic or only true sense) are not recognized, for minerals of the same type may arise independently from distinct solutions, or rocks from separate magmas, and yet be, so far as we now know, absolutely indistinguishable. Again, rocks of different generations may be indistinguishable; as, for example, a siliceous sandstone derived from a granite after the removal of all minerals except the quartz, and one derived by the erosion of a sandstone and the re-deposition of the sand grains thus derived. In general terms, there is no continuity of development in rocks and minerals, and no progressive differentiation, such as characterizes the organic world.

Thus it will be seen, that with our present conception of rocks and minerals, a true genetic classification based on the inorganic materials is not to be hoped for,—nor would it be desirable, since it would compel us to distinguish between materials otherwise exactly alike, but of independent origin. Nevertheless as far as practicable the principles underlying a genetic classification should be applied, and this can readily be done, if

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the classification is based on the agents to which the rocks owe their origin.

At the outset, a very natural subdivision of rocks into two great groups, the primitive and the derived or secondary,* suggests itself. Such a division would be strictly genetic and therefore desirable, were it not for the practical difficulty or impossibility of distinguishing secondary or derived chemical, from primitive rocks. Thus a granite formed by cooling from the primitive earth-magma would in itself be indistinguishable from the product of cooling after refusion. In like manner a gypsum or salt bed deposited from the primal ocean, would probably differ in no appreciable character from similar beds derived from solution and redeposition of these older beds. The same thing applies to rocks of organic origin, where solution or decay returns the material of the rock to the water or the atmosphere, from which it may be again abstracted and deposited by the organic agencies.

It is then apparent that secondary rocks of these types must for practical reasons be classed with primary rocks of the same groups, whereas mechanically formed rocks may be readily recognized as derivatives. This suggests the view above advanced, namely that the sub-division of the rocks most applicable from a practical point of view, is that which emphasizes the agent active in their production. Thus we may distinguish a group which owes its origin chiefly to chemical agents or agents acting from within, or so intimately associated with the forming rock mass that the process of formation may be called *endogenetic*. Endogenetic rocks may also be called nonclastic, since they are never composed of *fragments* of older rocks, as are the clastic rocks, though they include regenerated rocks, or those in which the material of the older rocks has gone back to the original state of fusion or solution, from which it is then redeposited in a chemical way. Contrasted with this group is that of the clastic rocks, or those made up of the fragments of older rocks. These owe their origin chiefly to agents acting from without, and hence may be termed *exogenetic*. These agents are chiefly mechanical, though in the formation of soil by atmospheric disintegration, we have chemical activities engaged in the removal of soluble constituents,

* The Protogenous and Deuterogenous of Nauman in part.

and the alteration of others. Nevertheless the agents active here are external, and the resultant detrital mass or residual soil must be included with the clastic or exogenetic rocks.

Returning now to the endogenetic or chemically deposited rocks, we may readily distinguish four groups, which, though of unequal quantitative value, with reference to their distribution in the earth's crust, are nevertheless of similar taxonomic importance. The first of these groups includes the well recognized Igneous rocks, to which the term *pyrogenic* is applicable. Kemp has clearly shown* that ice is to be classed as an ultra basic igneous rock, since water has the essential characteristics of a rock magma, though it is much less complex in composition, and is able to remain unsolidified at a much lower temperature than other magmas. This applies, however, only to water-ice. Snow-ice on the other hand is a truely sedimentary rock, which is separated from the atmosphere as snow, much as crystals of salt or gypsum are separated from water. The importance of snow and snow-ice as a rock can hardly be questioned, and it is also readily seen that they must be placed in a division by themselves, namely, the second, or atmospheric division, to which the name *atmogenic* is applicable.

The third great group of the endogenetic rocks comprises those ordinarily designated the chemical rocks, though it is manifestly incorrect to limit the term chemical to those rocks deposited from solution in water. But the term aqueous or *hydrogenic* is applicable to them and should be restricted to this group. It seems to me that the term "aqueous" is much less applicable to the clastic rocks generally included under this head, for in them water is only the external agent, as heat is in the pyro-clastics, which are not generally included with the igneous rocks. Thus the restriction of the term aqueous to the aqueo-chemical rocks, (hydrogenic) and the separation from them of the aqueo-mechanical rocks under the term *hydroclastic,* is in perfect accord with the practice of separating the igneo-chemical rocks under the term igneous (pyrogenic) from the igneo-mechanical rocks under the term pyroclastics.

These three groups, the pyrogenic, atmogenic, and hydrogenic, represent direct deposition, in a chemical manner, of materials from the three several states into which the primitive

* Handbook of Rocks.

earth magma became separated,—namely, the state of fusion, of aqueous solution, and of vapor,—and into one or more of which every rock mass is likely to return, on having its component materials chemically dissociated. (Compare diagram I.)

A fourth group of endogenetic rocks which is in a manner subsidiary to the other three, is the organic or *biogenic* group. The term "organic" is generally applied in a much more comprehensive sense, including not only those rocks directly due to the physiological activities of organisms, as coral reefs, shell heaps, or coal beds, but also rocks derived from these by mechanical agents. As an example of these latter may be mentioned clastic limestones, such as make up so large a part of our Palæozoic limestone beds, where the growing shell heaps or coral reefs are eroded and the resultant debris redeposited, while the reef or shell heap is still growing. It is true that in many cases, particularly where the uncemented shell heaps are worked over by the waves, undisturbed organic and clastic limestones may become intermingled and grade into each other imperceptibly. Yet if we bear in mind that classification should express relationship rather than differences, and that wherever the record is most complete in the inorganic as well as in the organic world, sharp lines of distinction do not exist, it becomes apparent that such intergradation can not be accepted as an argument in favor of uniting the rocks of purely organic origin with those derived from them while the organic agencies are still active. As well might we speak of the conglomerates and sandstones formed from the erosion of the lavas of an active volcano, either by atmospheric or aqueous agencies, as igneous rocks, unrelated to clastic rocks formed from lavas of extinct volcanoes.

Biogenic rocks fall naturally into two groups, those in which the material is derived from the air and those in which it is derived from the water. The former are due chiefly to the activities of plants (phytogenic) and the latter chiefly to those of animals (Zoögenic). Some phytogenic deposits, however, are derived from the water, as for example, those due to calcareous algæ, to diatoms, or the iron deposits due to bacteria; and some zoögenic rocks are derived from the atmosphere, i.e., deposits made by land animals. Nevertheless the most important organic deposits from the atmosphere are phytogenic (coals) and the most important from the water are zoögenic (organic limestones).

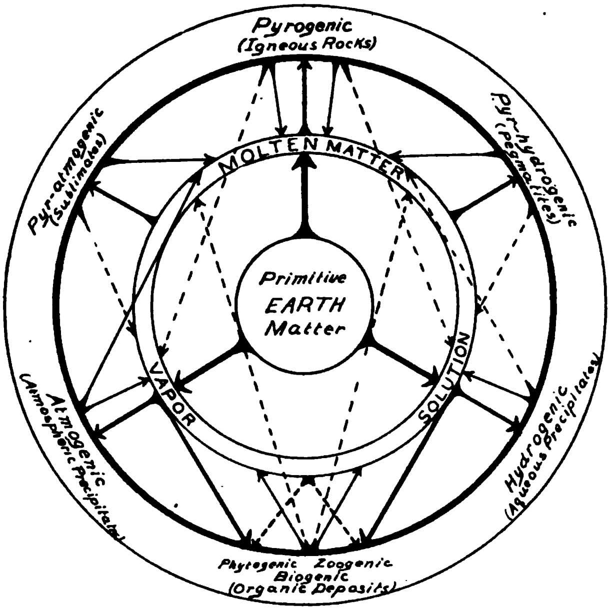

Diagram I.—Interrelations of the Endogenetic Rocks.

The material of the earth may be in three states before solidification, i. e., that of fusion, of solution in water, and that of vapor. From these states by direct deposition (endogenetically) we get the three types of fundamental rocks, the Igneous or *Pyrogenic*, the Aqueous or *Hydrogenic*, and the Atmospheric or *Atmogenic*. (Snow and snow-ice). By the physiological activities of organisms, we have formed the Organic or *Biogenic* rocks, the material of which is either derived from the Atmosphere (chiefly through plants—*Phytogenic*, though also in a minor degree through animals, as indicated by the heavy dotted line) or from the water (chiefly through animals—*Zoogenic*, though also in a minor degree through plants). The lighter arrows show to which states the rocks finally return, the dotted lines indicating the less likely change. Biogenic rocks are either vaporized or dissolved, hence the return arrows arise from the center. Pyro-atmogenic rocks, half way between Pyro and Atmogenic, are illustrated by sublimates, and Pyro-hydrogenic rocks, half way between Pyro and hydrogenic, by pegmatites.

We may omit further discussion of the pyrogenic or igneous rocks, as they have been made the special study of many investigators. The atmospheric rocks may likewise be dismissed, since the only important member of this group is snow, and its consolidation product,* snow-ice. The hydrogenic and biogenic rocks, on the other hand, together with the class of clastic

* Through diagenic metamorphism or diagenesis. See below.

or exogenetic rocks, still need much careful study. They are the rocks with which the stratigrapher is principally concerned, and stratigraphic descriptions will gain much in clearness and precision, when stratigraphers have ceased to regard the multiplication of definite and usable terms as less desirable than the present vague terminology.

In hydrogenic and biogenic rocks, composition is fully as important as in igneous rocks, and must be used as one of the primary means of classification. This is not the case however in the exogenetic rocks, where composition is a factor rather controlled by accident than otherwise. Hence composition takes a high classificatory rank in the endogenetic rocks while it becomes subordinate in the exogenetic class.

The chemical divisions of the hydrogenic and biogenic rocks are most satisfactorily based upon the basic elements. Only a few groups need to be considered as the majority of rocks fall under a limited number of divisions. The most important ones are: 1. Under the Hydrogenic (a) *Alkalious,* or those of the alkaline salts, with rock salt as the most important example. Deposits of soda and niter when of sufficient magnitude to be classed as rocks, also belong here. Carnallyte ($KCL\ MgCl_2\ 6H_2O$) forms a passage rock to the next group. (b) *Calcareous* and *magnesian,* or those of the alkaline earths. Most important among these are the carbonates: i.e., chemical limestones (including travertine, stalagmites and stalactites, etc.) and dolomytes (though many dolomytes are of secondary origin—i.e., the result of alteration (by diagenesis) of limestones) and the sulphates, gypsum and anhydrite. (c) *Siliceous* or the chemical deposits of silica, practically limited to the hydrous and anhydrous oxides of silicon, i.e. siliceous sinter or geyseryte, and deposits of chalcedony, jasper, vein quartz, etc. (d) *Ferruginous,* represented chiefly by the oxides and the carbonate of iron, the latter most generally with an admixture of clastic material, forming clay iron stones. This latter group may be considered transitional to the biogenic division of rocks, since some limonites are of truly organic (bacterial) origin and since the decay of organic matter furnishes the acids which are active in leaching out the iron to be redeposited in a concentrated state. It must, however, be borne in mind that this latter process does not involve any physiological functions of the organisms themselves, such as is going on in the formation of the true organic rocks.

Turning now to the biogenic or organic rocks, we find no pure organic salts of the alkali metals,* and hence our first column (a) remains a blank under this heading. Calcareous deposits, (b), however, are well represented, and it is here that the main source of calcareous deposits of both endo- and exogenetic types is to be sought. We may readily distinguish two groups, the unassorted or massive, and the assorted or stratified. The former include the reef rock formed by the growth in situ, of corals, Bryozoa, hydrocoralines, calcareous Algæ, etc. The latter comprise:

1. Shell beds, such as deposits of unbroken mollusk or brachiopod shells, echinoderm tests; the larger Foraminifera, etc.

2. Shell oozes, like chalk, Globigerina ooze, pteropod ooze, etc., and the limestones resulting from their solidification.

3. Crinoidal limestones, composed chiefly of the stems of crinoids which become dissociated on the death of the animal, and

4. Certain oolytes and other stratified deposits due to lime-secreting Algæ, and which are free to assume stratified character.

While all of these deposits may and frequently do occur in great purity, with the frail shells composing them scarcely broken, it is nevertheless true that they are very commonly in part composed of broken material, and thus approach the clastic condition. In fact it is here that we generally find an imperceptible transition to the clastic deposits (calcarenytes and calcilutytes) without being able to draw a line of distinction. Nor is it always possible after diagenesis, or alteration by static metamorphism, has set in, to determine the origin of a given rock mass.

Besides the carbonate of lime, the phosphate must be placed here. Such deposits may be derived from the accumulation of phosphatic shells, like those of certain brachiopods (Lingula) and of exoskeletons like those of the trilobites and other Crustacea, of which not inconsiderable accumulations are at times found. More pronounced than these, however, are the deposits

* The large percentage of ammonia salts in guano (31 per cent) which may even be greater than the phosphate of lime (22.5 per cent), suggests that this organic deposit is in part at least of this group.

of guano, but these frequently contain so high a proportion of alkalies, that they may be considered transitional between the first and second groups of the present table.

Siliceous organic deposits (c) in the unstratified or massive condition, formed chiefly through the agency of plants, occur in both fresh and salt water. But by far the largest deposits of organic silica are in the form of stratified oozes, such as radiolarian ooze, diatomaceous deposits and those composed of sponge spicules and other minute siliceous organisms. Flints and cherts are derived from these by a process of solution and redeposition in purely hydrogenic manner. Ferruginous organic deposits (d) comprise iron deposits due to the physiological activities of bacteria resulting in organic limonites, while carbonaceous rocks (e) must be considered in the light of our present knowledge as wholly of biogenic origin. Peat, lignyte, and bituminous coal are the typical carbonaceous biogenic rocks, the latter belonging in a measure to the alteration or diagenic products. Secondary derivatives through diagenic alteration are found in the hydrocarbons, petroleum, asphalt, etc., and further metamorphic products in some anthracite coals and in native coke.

As has already been indicated, a rock of any of the above groups does not generally remain for an indefinite period without becoming more or less altered, through the influence of the environment. Extreme alteration through the influence of heat, with or without accompanying pressure, is familiarly known as metamorphism. But there are a great many alterations of rocks which would not come under this head, unless the meaning of the term is extended to its limit, which, though desirable, is not always done. Walther has adapted the term diagenesis from V. Guembel, who used it in a somewhat different sense,* and applied it to *all those physical and chemical changes which a rock mass undergoes after its deposition, aside from those caused by pressure during orogenic disturbances and by igneous activity*. Deep seated alteration of igneous rocks, dehydration of gypsum, crystalization of organic limestones, and the various changes which vegetable deposits undergo, may serve as examples of diagenesis in the class of endogenetic rocks.

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* WALTHER, Johannes, *Einleitung in die Geologie*, s. 693.

From the diagenic changes in a rock mass, it is but a step farther in the same direction to those changes produced by metamorphism as ordinarily understood. Whether the metamorphism be due to contact with heated igneous masses (contact or thermo-metamorphism, or *aethobalism**) or to mountain making processes (regional or dynamo-metamorphism, or *symphrattism†*) the process, like diagenism must be considered as primarily a modifying one, and moreover one far more restricted in activity than diagenism. Nor can the product of such metamorphism be considered as a class apart from the original rock mass, any more than the product of diagenism. In other words, as Walther has maintained‡ the metamorphic derivatives of rocks must be classed with the original rocks in any classification based on genetic principles.

Walther has embodied the principles of genetic classification in a number of theses, of which those dealing with the present problem may be cited:

"Every ancient rock mass has *primary* characteristics, appearing at the formation of the mass, and *secondary* characteristics acquired through diagenism and metamorphism.

"These characters, developed at different times, may change the type of the rock to such an extent that the secondary characters appear to be the principal and the primary characters the accessory ones.

"In spite of this, primary characteristics alone determine the principal divisions of the lithologic system.

"Characters acquired through chemical diagenesis or through contact or pressure metamorphism, must serve as secondary means for the determination of smaller groups.

"The altered rock masses are to be placed with the original types." ||

To sum up, metamorphism may be considered as presenting itself under these phases, 1. Static metamorphism or *diagenism*, the product being *diagenic rocks*; 2. Contact or

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* From *αἰθός*, a burning heat, and *βάλλω*, to strike. Rocks of this type may be called *aethobalic rocks.*

† From *συμφράττω*, to press together. Rocks of this type may be called *symphrattic rocks.*

‡ Versuch einer Classification der Gesteine auf Grund der vergleichenden Lithogenie, *Congr. Geol. International, Compte rendu de la VII session, St. Petersbourg, 1897, 3me partie p. 9-25.*

|| Versuch einer Classification, etc., p. 18. See also KEMP, *Handbook of Rocks*, 2nd Edition, p. 11, where the same position is maintained.

TABLE I. THE ENDOGENETIC ROCKS.

PYROGENIC		For further subdivisions, see Kemp's Handbook of Rocks—Table of Igneous Rocks.				
ATMOGENIC		Snow.		Snow Ice.		
	Composition.	a. Alkalious.	b. Calcareous.	c. Siliceous.	d. Ferruginous.	e. Carbonaceous.
HYDROGENIC	Original	Rock salt, etc. Natural Soda.	Chemical limestones Stalactic deposits Calcareous Tufa Gypsum Anhydrite, etc.	Siliceous Sinter Vein Quartz. Flint, Chert, etc.	Bog ore, Limonytes, Siderytes, etc.	
	Metamorphic (Diagenic or Aethobalic or Symphrattic.)		Marble, Alabaster, etc.	Quartz rocks.	Specular Hematytes, Magnetytes, etc.	
BIOGENIC	Original.	Phosphate	Rocks. Organic Limestones (coral rock, Shell beds, organic ooze, etc.)	Siliceous organic oozes—diatomaceous earth.	Limonytes. (organic.)	Peat, Lignyte, Bituminous Coal, some Anthracytes, etc.
	Metamorphic (Diagenic or Aethobalic or Symphrattic.)		Marbles.	Quartz rock.	Specular Hematytes, Spathic and magnetic iron ores.	Certain Anthracytes, Native coke, Bitumens, Oils, Asphalt, Graphyte, etc.

thermo-metamorphism, or *aethobalism,* giving rise to *aethobalic rocks,* and 3. Dynamic or regional or pressure metamorphism (Druck metamorphose) i.e. *symphrattism,* resulting in the production of *symphrattic rocks.*

The Exogenetic or Clastic Rocks.

In discussing next the clastic rocks, the agent active in the production of their present characteristics will be considered as of primary importance in making the larger divisions. It is not always possible to determine what was the cause of the clastic condition of a given rock, since other agents subsequently active have produced those features which give the rock its most characteristic aspects. Thus a sand mass may owe its origin in part to atmospheric disintegration and in part to the mechanical activity of the water. Its final form, however, may be given by aeolian action, the mass becoming finally by diagenism a consolidated sand-dune. It will, however, be observed that the agent last active, and therefore the one whose characteristics were most strongly impressed upon the mass, i.e. the wind, is not only responsible for the form and structure which the deposit eventually takes on, but also, in part at least, modifies the original form of the component grains. Thus without overlooking the claims of the other agents, those of the wind may be considered as greatest and the rock is therefore placed under the division of wind-formed clastics or anemoclastics.

The relative claims of the various agents active in the production of a given clastic rock once determined;—provided there is more than one agent,—it will be found that most rocks fall under one of five groups, though some rocks may fall so precisely half way between two groups, that it becomes a matter of individual opinion where it should be placed. The five principal groups are: Pyroclastic, Autoclastic, Atmoclastic (including Anemoclastic), Hydroclastic and Bioclastic. (See diagram 2.)

The *Pyroclastic* group is most typically represented by the tuffs, volcanic breccias, etc. These may grade insensibly into the group of *hydroclastics.* From the nature of the agent active in their production it will be seen that they are most nearly related to the pyrogenic rocks in the endogenetic division. That they themselves belong to the exogenetic group, will scarcely be questioned, for although the explosion which brings about the clastic condition of the lavas within, or the rocks surrounding the volcanic vent, occurs within the earth, it is external with reference to the rock mass affected.

While the rocks chiefly involved in the destruction due to the volcanic explosions are the lavas—fresh and old, and the previously formed tuffs, etc., composing the volcano,—the basement rocks may also be involved, thus producing non-igneous pyroclastics, which are, however, of relatively slight importance. Rocks shattered by earthquakes form a connecting link between the true pyroclastics and the autoclastics. The limiting states of pyroclastic activity are vaporization on the one hand, and fusion on the other, or the return of the matter to such states from which it may be redeposited in an endogenetic manner.

The *Autoclastic* group of rocks comprises all rocks shattered or crushed within the earth either by pressure of one rock mass upon the other, or by movement of rocks over each other. Fault-breccias and the material of "crush zones" must be classed here, while earthquake shattered rocks may also be included here, though as before noted, they are transitional to the pyroclastics. By far the most important autoclastic products, however, are those resulting from glacial erosion. Ice, and all the material frozen in it, is a part of the earth's crust while it exists, and hence any material ground up between the ice and the rock on which it moves, is of the type of the material crushed between other moving rock masses (fault breccia). Furthermore, since all *ice-transported* material has received its most characteristic features from that agent, we may with propriety include such material in this group, even though it was originally broken by atmospheric agencies (atmoclastic). In other words, I would consider all glacial material—exclusive of such as has been worked over by water—as belonging to the group of autoclastic rock material—and if consolidated forming autoclastic rocks, just as I would consider consolidated wind-blown material as aeolian or anemoclastic rock, whether or not the wind was chief factor in causing the fragmental condition.

The *Atmoclastic group* typically comprises rocks broken up in situ, either by chemical or mechanical means, and recemented without further rearrangement by wind or water. Perhaps the most typical example is to be found in the lateryte, which if consolidated without disturbance, would give us a rock in which siliceous clay rocks (siliceous argillutytes) are more or less admixed with complex coarse fragmentary residual rocks (rudytes) of varying composition. As a group of somewhat minor rank under this division, must be placed the aeolian or *anemoclastic* rocks already referred to. Here belong the æolian limestones of the Bermudas (anemoclastic calcarentytes) and here also belongs the æolian loess.

The *Hydroclastic* group comprises by far the largest number of types of clastic rocks. All water-laid deposits of clastic material belong here, though the most typical examples are such as owe both their clastic condition and their position to the waves. Here belong the great classes of stratified conglomerates, sandstones, slates and shales, and here also belong the great beds of clastic limestone, resulting either from the mechanical erosion and redeposition of growing coral reefs or shell deposits, or from the mechanical working-over of older limestones.

While typical hydroclastics are easily recognized, it is apparent that gradations between this and the other groups exist, and that in some cases it becomes a matter of judgment as to where a given rock is to be placed. As already noted, the gradation from pure pyroclastics to pure hydroclastics may be a complete one, and the same may be said of the gradations between the hydro- and the atmoclastics.

The *Bioclastic* group appears at first thought to be represented by so small a number of rocks as to be wholly out of proportion to the others. But when we add to the rocks broken by plants and those ground up by Crustacea or fish on coral reefs, the great varieties of rocks for which man is responsible, the representation swells out to very noticeable proportions. Thus bricks (as material)* plaster, concrete, cement and all other rocks which receive their characteristic features through man's agency, fall naturally into the system, and thereby into their proper relations to all other rocks. Where gravel and sand is used in the manufacture of concrete, we have rocks in.

* Strictly speaking bricks, when classed as rocks, must be considered as aethobalic bioclastics.

which the essential character of the material is due to the mechanical work of the water. Such a rock may still be considered as bioclastic, but constituting a passage rock to the hydroclastics. Again, bricks made from clay which itself is atmoclastic, i.e. due to the disintegration of shales or of feldspathic rocks, serve to connect the atmoclastic and bioclastic groups.

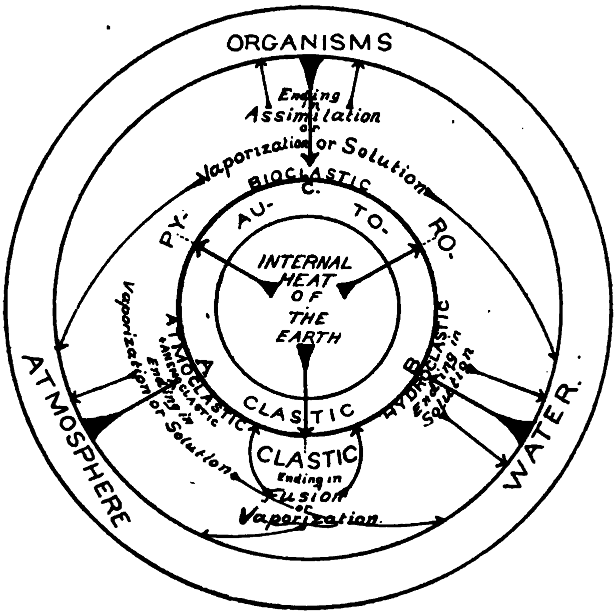

DIAGRAM II.—INTERRELATIONS OF THE EXOGENETIC ROCKS.

A. B. C represents the crust of the earth. From within the crust, but still external as far as the rocks are concerned, volcanic explosions produce the *Pyroclastic* rocks on the surface of the crust. Within the crust itself, the *Autoclastic* rocks are formed, while from without, the atmosphere, water, and organisms attack the crust, producing *Atmoclastic* (including *Anemoclastic*), *Hydroclastic*, and *Bioclastic* rocks. The final result of the destructive work of the various agents, returns the material of the rocks either to the air, to the state of solution in water, or to a state of fusion. A part may remain as assimilated organic matter and be redeposited biogenetically as new rock. The remainder will be redeposited from the various states to which it has been returned, by the corresponding endogenetic agents.

The hydroclastic condition of rocks terminates in a state of solution, which is the ultimate degree of destruction water can effect. The atmosphere likewise may bring about solution by the aid of its vapors (corrosion), and so may organisms. Solution then is one of the limiting stages of the clastic condition in either atmo-, hydro- or bio-clastic rocks. In the atmoclastic group vaporization is another limiting stage for some rocks, the material of the rock returning to the atmosphere, through the agency of the atmosphere (snow, ice). Finally bioclastic rocks may be dissolved or vaporized* through the agency of organisms (chiefly man), while to a minor degree, the rocks destroyed by organisms may also be assimilated. Thus the material of the clastic rocks may eventually be returned to the atmosphere or the water, or else it may pass into a state of fusion. From these states it may then be redeposited by endogenetic agencies. (See diagram 2.)

In the further subdivision of the clastic rocks, texture or size of grain takes precedence over chemical composition, since, as has already been noted, the latter is controlled by accident. We commonly recognize three sizes of grain, 1st that larger than what is commonly considered the normal sand-grain, 2d, the sand-grain, and 3d, the rock flour or impalpable powder. The first texture is most appropriately called *rudaceous* (from *rudus*, rubble). The consolidated rock whether conglomerate or breccia may be called a *rudyte*. The term psephyte has been used in this sense, for siliceous rocks, but it is a much less adaptable one. The second texture, i.e. the sand-grain, is familiarly known as *arenaceous* (from *arena*, sand), though that term is often used also to indicate that the rock in question is siliceous. The term *arenyte* may be used for consolidated rocks with this texture, of whatever composition they may be. For siliceous rocks of this type the term psammyte has been used. The third texture, finally, may be designated by the term *lutaceous* (from *lutum*, mud), and for consolidated rocks of this type the term *lutyte* may be used, irrespective of chemical composition. Pelyte has been used particularly for argillaceous rocks of this group.

When a clastic rock is nearly or quite pure in chemical composition, as not infrequently happens, we can combine chemical and textural terms. Thus a purely siliceous arenyte like the St. Peter's sandstone of the Mississippi valley (over [illegible] per cent. SiO_2) may be called a [illegible], while a pure quartz conglomerate or breccia would be a [illegible]. A rock composed [illegible] of quartz flour would be a pure [illegible]

* The best [illegible]

tyte. Again, a pure limestone conglomerate or breccia, is a *calcirudyte,** a lime sandstone like that of the Bermudas (anemoclastic) or like the great beds of Palæozoic clastic lime-sand-rocks of the middle west (hydroclastic) are *calcarenytes,* while rocks made up of lime-flour like many beds in the Palæozoics, and the lithographic stone, are pure *calcilutytes.* Waterlimes are siliceous or argillaceous calcilutytes as the case may be.

Clay rocks, whether pure or impure, are generally known by the structural terms shales or slates. They are always *lutytes,* and when pure may be called by the name *argillutyte.* Most generally shales or slates are more or less siliceous or calcareous argillutytes, or they may be highly carbonaceous argillutytes, in which case they are known by the misleading term "pyroschists." Rudytes in which argillaceous material predominates either in the fragments or in the cement, are not unknown, but pure argillirudytes are probably represented only by local examples.

The three types of composition mentioned above cover the most important cases. Impure types bridge the chasms between the pure types. Thus, besides those mentioned, there are calcareous, argillaceous or ferruginous silicarenytes and silicilutytes, and likewise argillaceous, siliceous and carbonaceous calcarenytes and calcilutytes. Besides, there are micaceous feldspatic or glauconitic silicarenytes, and micaceous calcarenytes. Strongly feldspatic arenytes or arkoses and glauconitic arenytes or green-sand rocks are further modifications of the types.

Finally there may be in disturbed iron or coal regions autoclastic ferrirudytes, or carborudytes, (iron breccias or coal breccias) or even ferrarenytes and ferrilutytes, or carbarenytes and carbolutytes. All these, however, will be represented by local examples only.

The divisions made in the endogenetic group, into original and metamorphic, may also be carried out in the exogenetic group. We may, however, substitute here the terms unconsolidated and consolidated for original, and for the early stages of diagenism. The solidification or lithification of clastic rocks by chemical means, is clearly a process of diagenic action, but diagenism does not stop here, there being numerous changes which a clastic rock may suffer after solidification, which are

* Grabau *Bull. Geol. Soc. Amer.*, vol. xiv, p. 349.

TABLE II.—A TABLE OF THE

	Texture.	RUDACEOUS.			
	Composition	Unconsolidated.	Consolidated. (rudytes.)	Metamorphic.	Unconsolidated
PYRO-CLASTIC	Chiefly complex silicates.	Volcanic blocks, bombs, or lapilli.	Volcanic Breccia and Agglomerates etc. (Pyrorudytes.)	Meta-breccia Meta-agglomerate.	Volcanic sand.
AUTO-CLASTIC	Varied according to composition of original rock mass. Sometimes purely siliceous or calcareous.	Fault rubble Boulder clay Boulder moraine	Fault breccia. Coarse, unstratified pudding stones. (Autorudytes.)	Meta-breccia. Meta-pudding-stone.	Autoclastic sand Unassorted glacial sand.
ATMO-CLASTIC	Generally complex except when original rock-mass is simple.	Talus rubble; generally complex silicates, but sometimes pure silica or or lime.	Breccia. (Complex atmorudytes, sometimes atmosilicirudytes or atmocalcirudytes.	Meta-breccia Quartzytes. Marbles.	Disintegration sands (granitic) sometimes pure siliceous or calcareous sands.
ANEMO-CLASTIC	1 Siliceous	. . . .	. . . .	. . . .	1 Wind blown quartz sand.
	2 Calcareous	. . . .	. . . .	. . . .	2 Wind blown lime sand.
	3 Argil'aceous (usually quite pure).	. . . .	. . . .	. . . .	. . . .
HYDRO-CLASTIC	A. Simple. 1. Siliceous. a. pure. b. impure.	a. Quartz pebbles. b. Miscellaneous gravel, quartz predominant.	a. Quartz conglomerate (Hydrosilicirudytes.) b. Composite rudytes with pebbles of crystalline or of mixed rock, with the quartz. (Impure Hydrosilicirudytes.)	Meta conglomerate.	a. Quartz sand, beach, river or glacial wash sand. b. Micaceous, feldspathic, glauconitic, etc. quartz sands. c. Glauconite sands.
	2. Calcareous a. pure. b. impure.	a. Calc rubble of corals, shells, etc. or of older limestones. b. Calc rubble with siliceous or crystalline fragments, or siliceous or argillaceous paste.	a. Pure lime conglomerate or calcirudites. (Hydrocalcirudytes) b. Siliceous, argillaceous or complex calcirudytes. (ImpureHydrocalcirudytes.)	a Marble. b. Impure marble.	a. Calc sand. b. Silicious, argillaceous ferruginous calc sand.
	3. Argillaceous. a. pure. b. impure.	Local Local	Examples. Examples.	. . . .	Local Local
	B. Complex.	Crystalline gravel.	Complex conglomerate. (Complex Hydrorudytes.)	Meta-conglomerate.	Silicate sands.
BIO-CLASTIC	Complex or simple. (Siliceous, calcareous, argillaceous, carbonaceous etc.)	Rubble of broken or crushed stones of varying type.	Concretes etc. (Biorudytes)		Ground up rock.

EXOGENETIC OR CLASTIC ROCKS.

ARENACEOUS.		LUTACEOUS.		
Consolidated (arenytes.)	**Metamorphic**	**Unconsolidated**	**Consolidated. (lutytes.)**	**Metamorphic.**
Volcanic arenytes or coarse tuffs (Pyrarenytes.)	Hornblende schists, etc.	Volcanic ashes and mud.	Volcanic ashtuffs. (Pyrolutytes.)	Hornblende. schist, etc.
Unstratified sandstones, greywackes, etc. (Usually impure autoarenytes, but sometimes pure autosilicarenytes or autocalcarenytes.)	Various schists, etc. (quartzytes, marbles)	Rock flour, glacial till and unassorted glacial clays with few or no boulders or sand.	Greywack slates, etc. (Autolutytes, impure auto-argillutytes, etc.)	Quartzytes, etc. Argillytes, Phyllytes, mica-schist, etc.
Arkoses or Feldspar arenytes. (Atmoarenytes, sometimes pure Atmosilicarenytes or Atmocalcarenytes.)	Paragneisses, etc. (Quartzytes, marbles)	Lateryte, and all clays formed in situ.	Argillutytes, often Siliceous or ferruginous (Atmoargillutytes.)	Slates, argillytes and schist of varying type.
1 Aeolian quartz sandstone(Anemosilicarenyte) 2 Aeolian limestone (Anemocalcarenyte)	1. Quartzytes, schists, etc. 2. Marbles.	3. Loess, dust deposits, (generally quite impure clays).	3 Impure clay rocks (Siliceous or calcareous anemoargillutytes.)	3. Argillytes, schists of varying type, etc.
a Waterlaid quartz sandstone. (Hydrosilicarenytes.) b. Micaceous feldspathic, glauconitic, etc. silicarenytes. (Impure Hydrosilicarenytes.) C. Glauconaienytes.	a. Quartzytes. b. Mica quartzytes, mica schists, etc.	a. Quartz muds, (off-shore oozes). b. Argillaceous or calcareous quartz mud.	a. Comparct quartz mud rocks, Novaculyte, or whet-stones. (Hydrosilicilutytes.) b. Argillaceous or calcareous silicilutytes. (Impure Hydrosilicilutytes.)	a. Quartz rock. b. Slates, schist, hornfels, etc., etc
a Water laid calcarenyte. (Hydrocalcarenyte.) b. Siliceous, argillaceous or ferruginous calcarenytes (Impure Hydrocalcarenytes.)	a. Dolomytes and numerous alteration products, marbles, etc. b. Garnet rock, Calchornfels, micaceous marbles, etc.	a. Calc mud. b. Siliceous, argillaceous, or carbonaceous calc mud.	a. Waterlaid calcilutyte. (Hydrocalcilutyte) b. Siliceous, argillaceous, or carbonaceous calcilutytes. (Impure Hydrocalcilutytes.)	a. As under calcarenytes. b. As under calcarenytes.
Examples Examples		a. Water-laid clays or kaolins. b. Impure water-laid clays,—siliceous, calcareous, carbonaceous, etc.	a. Shales, clay rock of various types—i. e. pure argillutytes (Hydrargillutytes.) b. Shales, Siliceous, calcareous or carbonaceous argillutytes. (Impure Hydrargillutytes.)	a. Slates, argillytes, Porcelanytes, etc. b. Shales, phyllytes, various schist, pyroschist, etc.
Siliceous Arenytes (Siliceous Hydrarenytes.)	Schists, paragneisses, etc.	Water-laid rock-flour —chiefly ground up silicates.	Siliceous lutytes. (Siliceous Hydrolutytes.)	Schist, etc.
(Bioarenytes.)		Pulverized rock, prepared brick clay, etc.	Cement, plaster, sun-dried bricks, etc. (Biolutytes.)	Burnt brick, etc. (as material.)

not referable to either dynamic or thermic metamorphism. As examples of such further diagenic action may be cited the deposition of secondary silica around sand grains, and the crystallization of such silica in optical continuity with the original grain; the crystallization of clastic limestones, and others of this type. The products of æthobalism and symphrattism, i.e. the æthobalic and symphrattic clastics need not be further considered here. Their proper position in the system is after the diagenic members of the same group.

Note on the use of the Table of Exogenetic rocks.

Any clastic rock may generally be at once placed under one of the three textural groups *rudyte, arenyte,* or *lutyte,* which grouping is best considered first purely for convenience sake. Sometimes nothing more can be determined about a given rock, without special chemical or microscopic examination. When the composition is determined, a further step is made in the classification, but the primary group can generally not yet be ascertained. If the rock is of simple composition, and pure, it may be classed as follows: If pure silica, as a silicirudyte, silicarenyte, or silicilutyte; or if impure, as a calcareous, argillaceous, feldspatic, glauconitic, micaceous, etc., silicirudyte, silicarenyte, or silicilutyte. If pure lime, it is a calcirudyte, calcarenyte or calcilutyte; or if impure, a siliceous, argillaceous, magnesian, ferruginous, carbonaceous, etc., calcirudyte, calcarenyte or calcilutyte. Finally if pure clay (kaolin), it is an argillutyte, though most commonly the rock would prove a siliceous or calcareous or carbonaceous argillutyte. If the rock is complex in composition, with neither free quartz, lime nor clay predominating to give it a distinctive character, it may still be a siliceous (silicate) rudyte, arenyte or lutyte, as the case may be, or it may even be an argillaceous or calcareous rudyte, or arenyte, where those minerals are present in minor quantity.

So far the determinations are generally possible from hand specimens. But not until its primary relations, i.e. its geologic or field relations, are determined, can the rock be placed in its primary group. Exceptions to this are fossiliferous rocks, and rocks belonging to the pyroclastic or bioclastic divisions, which can generally be recognized in hand specimens. The pyroclastics and bioclastics may at once be classed as pyrorudytes, (volcanic breccias, etc.) pyrarenyte, or pyrolutytes (volcanic tuffs, etc.), or as biorudytes, bioarenytes, or biolutytes. When the field relations of the other rocks are determined, they may be classed as autoclastics, i.e. autorudytes autoarenytes, or autolutytes; as atmoclastic, i.e. atmorudytes atmoarenytes or atmolutytes, generally of complex composition; as anemoclastic, i.e. anemorarenytes, or anemolultytes, (when pure as anemosilicarenyte, anemocalcarenyte, etc.); or as hydroclastics, i.e. hydrorudytes, hydrarenytes, or hydrolutytes, or when pure as hydrosilicirudytes -arenytes, or -lutytes, as hydrocalcirudytes, -arenytes, or -lutytes, or as hydrargillutytes, according to composition. Siliceous hydrargillutytes comprise many of our Palæozoic siliceous mud-stones, while most of the typical shales of the Palæozoic, are calcareous hydrargillutytes. The Genesee shale (slate?) of western New York is a siliceous and carbonaceous hydrargillutyte. In all these cases of course the prefix "hydro" can be omitted, as the rock is understood to be of hydroclastic origin.

The compound terms here given may be found useful in descriptive writing, especially as they are almost self-explanatory. Petrographers may find it desirable in the future, to coin special names for special types under the different groups. Thus the anemoclastic calcarenyte (anemocalcarenyte) of the Bermudas may be called *bermudyte,* and the name retained for that type elsewhere. Or the hydroclastic calcilutytes (hydrocalcilutytes) of Petoskey may be called *petoskeytes,* and the name restricted to all hydrocalcilutytes which are derived from the ground-up mud of ancient coral reefs and deposited in the neighborhood of the reef. In like manner the magnesian hydrocalcilutytes of the Beaver islands, lake Michigan, which are not directly derived from organic deposits (zoogenic calc rocks), might be called *beaverytes,* and the name restricted to rocks of that origin, texture and composition. Stratigraphers, however, will scarcely need terms more precise than those here given.

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THE BRAGDON FORMATION IN NORTHWESTERN CALIFORNIA.

By Oscar H. Hershey, Berkeley, California.

INTRODUCTION.

When I first arrived in California, in 1897, I was supplied with a geological map of the United States, extracted from an Annual Report of the U. S. Geological Survey. On this map, certain areas in northwestern California were represented as Carboniferous and certain others as Jura-Trias. One of the latter included the territory in which I began to prospect and in this manner I derived my first intimation that the rocks of Trinity mountain are Mesozoic in age.

I spent several months in the vicinity of Bragdon, in Trinity valley, and became somewhat familiar with the geological relations of the rocks of Trinity mountain. I learned that the contact between a certain volcanic series and an overlying black slate and quartzyte series is the principal gold "pocket" horizon of that territory and naturally I devoted a large portion of my time to the investigation of that contact. I panned up to it, I followed it continuously for miles and I dug along it repeatedly. It has been suggested to me from time to time by geologists who have not given close attention to that contact that the volcanic material lies under the slates because of intrusion, but all the phenomena I have ever been able to observe along that contact indicate unmistakably that the Bragdon sediments were laid down upon the volcanic series. This position I have maintained in a paper published in July, 1899, another in April, 1901, and yet another in April, 1903.*

As I extended my field of operations I found in Trinity county an entirely different slate series whose stratigraphic position seemed under the volcanic series, and I temporarily denominated it the "Lower Slate Series" to distinguish it from the "Upper Slate Series" or Bragdon formation.

* "Origin and Age of Certain Gold 'Pocket' Deposits in Northern California," Amer. Geol., vol. xxiv, July, 1899.
"Metamorphic Formations of Northwestern California," Amer. Geol., vol. xxvii, April, 1901.
"Structure of the Southern Portion of the Klamath Mountains, California," Amer. Geol., vol. xxxi, April, 1903.

Presently I began to read the reports of the U. S. Geological Survey on the rocks of the Sierra Nevada region and recognized in the descriptions, a similarity of the Calaveras formation to the Lower Slate series and the Mariposa formation to the Bragdon formation, while my volcanic material seemed to have its counterpart in the "Diabase and Porphyrite" series of the Sierra Nevada province. Because of its evident rather close relation to the Bragdon slates, I provisionally classed the volcanic series as Jurassic in age.

In September, 1901, I visited Mr. Diller's camp at Copley, going with him to Shasta. In the course of our discussions of the rocks of that region, he informed me of his discovery shortly before, that the great volcanic series of tuffs and lavas rests unconformably on the Carboniferous and Devonian, but seems to pass conformably under the Pit shales of Triassic age, so that it seemed pretty definitely to belong in large part to the Triassic series of rocks. I then made a reconnaisance trip into the Pit River and Squaw Creek country, following an itinerary laid out for me by Mr. Diller and was able to verify to my entire satisfaction the evidence of the Triassic age of the volcanic series which goes under the Bragdon slates. Since then I have considered the Clear Creek volcanic series, wherever it occurs, as far west nearly as South Fork mountain, as essentially rather early Triassic in age, but as the announcement of the discovery properly belonged to Mr. Diller, I have heretofore avoided definite reference to its Triassic age. However, in the treatment of the subject of this paper, I am compelled to freely handle the volcanic series and its structural relations. Mr. Diller has recently indicated his idea of the age of this series, having found Triassic fossils in some of the later tuffs.*

In October, 1901, while following the "Mother Lode" from Plymouth to Jacksonville and between Mariposa and Princeton, I had an opportunity of becoming familiar with the characteristics of the Mariposa formation and was impressed by the strong resemblance between it and the Bragdon formation. At several places I observed conglomerates similar to those in the Bragdon formation. The Mariposa formation as developed in the Sierra Nevada areas more nearly resembles the southern

* "Copper Deposits of the Redding Region, California," *U. S. Geol. Sur.*, Bull. No. 233, p. 124.

portion of the main western Bragdon area than the eastern or type area.

Mr. F. M. Anderson, in conversation with me, suggested that the age of the Bragdon formation might be Devonian because of its occurring west of a Carboniferous belt in a region in which there seems to be a general eastward succession of the strata so far as age is concerned, but subsequently he seems to have hit upon the Triassic as the period which best fitted his observations of the slates of Trinity mountain.*

I have found no fossils in the Bragdon formation except imperfect plant impressions near Whitney's in the valley of Clear creek, near Van Ness mine on the opposite side of the Trinity range and at various places along the trails between Trinity Center and Slatonis and Delta. They invariably occur in a peculiar sandy shale. Mr. Diller has since found plant remains in similar strata near Slatonis and has taken considerable pains to have them identified, submitting them to Fontaine, Ward, White and Knowlton, but while the most definite opinion expressed seems to support a Jurassic age, the fossils are too imperfect to be of any weight whatever in deciding whether the Bragdon formation is Carboniferous, Triassic or Jurassic in age, so that unless better fossil material be discovered in the future, we will be compelled to fall back on stratigraphic evidence in fixing the probable age of the formation.

Mr. Diller has recently discussed† at some length the Bragdon formation, giving all the available paleobotanical evidence and provisionally placing it at the base of the Carboniferous section of the Sacramento River region. This conclusion he bases upon his study of its areal distribution and stratigraphic relations, a method of procedure very similar to that by which I have concluded that it is probably late Jurassic in age. Mr. Diller states that I have referred it to the Jurassic largely on lithologic evidence which was true in the earlier stages of my study of it, but in the past two years I have gathered a large amount of additional data which lead me, more strongly now than ever, to maintain its late Jurassic age on broad structural or stratigraphic grounds in addition to the lithologic evidence and the purpose of this paper is to place this material in detail

* California State Mining Bureau, Copper Resources of California—Geological Map of the western part of Shasta County.

† "Klamath Mountain Section of California," *Amer. Jour. Sci.*, vol. xv, May, 1903.

before the geologic public. It is warranted by the importance and interesting character of the formation, for in the Bragdon series lies the record of a peculiar event in California geology.

THE EASTERN OR TYPE AREA.

The principal and least altered area of the Bragdon formation lies in the eastern portion of Trinity county and the western portion of Shasta county, mainly in what may be called the Trinity Mountain country. It is roughly oval in outline, its major axis trending north-northeast to south-southwest. It has a length of about thirty miles, a width of ten to twenty miles with a probable average of about fifteen miles, and in addition there is a spur twelve miles in length and two to four miles wide extending southeastward to Ono in the Sacramento valley. The northeastern portion is trenched by the Sacramento river both above and below Delta, the Trinity river traverses it near the western border, and Clear Creek emerges from it about a mile below the Tower House. In the central portion, the formation outcrops without interruption over broad areas, but around the borders, especially on the western side, small masses have been isolated, by erosion, from the main era.

The formation is a succession of black, laminated shales and blue-gray quartzytes, with conglomerates locally developed. The bedding is regular and very prominent at nearly every outcrop. Layers of black, thin-bedded, hard shales (or slates as I have formerly denominated them because of their alteration) from ten to fifty feet thick alternate with heavy-bedded layers of coarse sandstone two to five feet thick, although layers ten to twenty-five feet thick are not uncommon. Where the formation lies nearly horizontal, extensive outcrops as seen from a distance have a banded appearance, as in the high bluff at the bridge near Trinity Center.

Except in a contact metamorphic zone near Lewiston, the shales have not been metamorphosed to the extent of the development of mica, but they have been silicified, so that they resist weathering and fragments commonly lie about on the surface in flat pieces. The black color I suppose to be due to carbon. The shales in many places weather to a light yellow color, as along the stage road crossing Trinity mountain between French Gulch and Trinity Center. The distinct lamination has generally escaped destruction, but the formation is traversed in various directions by narrow shear zones in which the shales have been crushed into a black, glistening schistose slate. This is its appearance in most of the mines of the area because along the veins there has usually been faulting and shearing. But in traveling over the area one is usually impressed with the fact that dynamical metamorphism has been generally absent.

The conglomerates are the most characteristic portion of the series. They occur throughout this eastern area, but are most strongly developed toward the northeast, in the vicinity of the Sacramento river. Along the Trinity Mountain belt, there are areas acres in extent which are bestrewn with angular fragments of all sizes up to three feet in diameter, of gray conglomerate in which the pebbles are mostly between one-fourth inch and one inch in diameter, and consist almost exclusively of variously colored cherts, including red and black, all of which can be referred for an origin to the Paleozoic rocks. Some of the fragments, lying in the beds of creeks, attract attention by their speckled appearance. The lithification has continued to the extent that the rock fractures through the pebbles rather than around their borders. The thickness of the layers must be in places from ten to fifty feet. There seem to be locally heavier developments as near Deadwood, French Gulch and along the new wagon road intended to connect Trinity Center with Delta. One may cross Trinity mountain along other lines without much noticing conglomerate fragments. In Trinity valley, the conglomerates do not appear at the base of the series, but are scattered through the formation to a considerable height above the base. Near the Sacramento river, I believe Mr. Diller has found some of this conglomerate at the base of the series, resting on the Paleozoic rocks.

There is nothing in the stratification in Trinity mountain and westward to indicate beach conditions, but in the thickening and coarsening of the conglomerates in the direction of the Sacramento river, we probably have evidence of an approach to the eastern shore-line of the Bragdon body of water. The conglomerates in that region are supplied with limestone pebbles which weather out near the surface and give the rock a vesicular appearance. This may be seen from the train in approaching Delta from the south. Mr. Diller has found that the limestone pebbles contain Devonian fossils referable to the horizon represented near Kennett.* Apparently they have not traveled far from the parent ledges. On the western slope of Trinity mountain, limestone pebbles are absent or sufficiently rare to have escaped notice.

Supposing the shore-line to have been a short distance east of the site of the Sacramento river near Delta, the conglomerates occurring near Trinity river, not at the base, but in the body of the shales, may have been carried by current action fifteen miles or more from the coast. Beyond that the conglomerates thin and wedge out or are reduced to coarse sandstones.

Sandstones, silicified into quartzyte, occur plentifully in Trinity mountain. Some layers appear to be composed principally of fine chert grains, but others (gray in color, yellowish on outcrop) resemble, somewhat, fine waterlaid tuffs. However, I am unable to say that there is any volcanic material in these layers. Near the summit of Trinity mountain, south of Deadwood, I have observed thin-bedded sandstones which were rather friable and not much altered. The hard blue-gray quartzytes outcrop readily and the soil is largely covered by their debris.

Roughly estimating from memory, I should say that nearly one-third of the formation is sandstone (or quartzyte) and conglomerate and the remainder shale.

The maximum thickness I have been estimating at 2000 feet. Under some of the peaks of Trinity mountain, the formation has a vertical range of 3000 or 4000 feet, but I have always made an allowance for an exaggeration of the apparent thickness of the series by folding and faulting. The highest peaks of this region, if not igneous material, are Bragdon strata and probably the original surface is everywhere gone.

There is a total absence, in this Bragdon area, of limestone and of chert, except as fragments in the conglomerates already mentioned. In this respect the series contrasts strongly with all the Paleozoic formations. The soil over the Devonian and to a slighter extent over the Carboniferous rocks abounds in chert fragments which are continually evident to the field geologist, but he finds no trace of chert over the Bragdon shales, except

* *Amer. Jour. Sci.*, vol. xv, May, 1903, p. 352.

as the debris of the conglomerates. Instead, he finds abundant fragments of the shale and quartzyte in the soil and bestrewing the surface. Whenever I cross the line from the Paleozoic rocks to the Bragdon rocks I know it almost instantly by the sudden change in the surface debris.

THE CLEAR CREEK VOLCANIC SERIES.

As the Bragdon series in the eastern area is nearly everywhere underlaid by a sheet of surface volcanic materials consisting of lavas, tuffs and dikes, it is necessary to discuss the latter at some length. Through information derived from Mr. Diller and also Mr. F. M. Anderson, supplemented by a little observation of my own, I am aware that these volcanic materials were originally mainly andesyte and rhyolyte and are now altered to rocks abounding in sericite, chlorite and epidote, but for the purpose of this paper I will refer to their original rather than their present condition.

The earlier eruptions appear to have been more basic in character than the later, so that the lower portion of the series was prevailingly andesitic in character, although it is possible that there may have been some basalts included. By alteration, these rocks have been nearly uniformly converted to a dull greenish color and I formerly termed them greenstone. This kind of rock constitutes the bulk of the series and where erosion has cut deeply into it, the greenstone may be the only rock left. That is the case generally in the western areas. The Clear Creek areas are traversed by narrow shear zones as are the Bragdon areas and in them the greenstone has been converted to a schist somewhat resembling the amphibolite schist of the Sierra Nevada region. But the greater portion of the series has suffered little or no dynamical metamorphism. There is, in consequence, little difficulty in distinguishing between those portions of the greenstone which were originally lavas (often vesicular) and those portions which were tuffs. I distinguish the tuffs from brecciated lava sheets by the heterogeneity of the fragments, compact and vesicular fragments of different varieties of lava being mixed together. The fragmentals are frequently coarse and in thick layers alternating with compact greenstone, vesicular in places. In addition to these very evident lava sheets and tuff layers, there are more coarsely crystalline portions of the formation which I suspect to have been dikes binding together the stratified members or perhaps in part very thick lava sheets. Certain partially altered, fine-grained diabasic rocks undoubtedly occur in the form of dikes.

Where the upper portion of the series is preserved as in the vicinity of the Sacramento river and in the Pit River section, altered rhyolytes are common. They appear to be partly in the form of sheets, partly fragmental and partly as dikes rising through the altered andesyte. Much of the rhyolyte contained quartz phenocrysts which have escaped destruction. This altered rhyolyte outcrops in belts which are broad where they occur in the east, but narrow in the west where erosion has cut deeper into the series. I have never given sufficient attention to the Shasta County country to learn just what is the structure which causes belts of altered rhyolyte to traverse the altered andesyte areas, but I am inclined to believe that it is due partly to the infolding of the rhyolyte sheets with the andesyte and partly to rhyolyte dikes. Mr. Diller has just completed a thorough study of that territory and he will give us more precise information about it; for the present purpose it is sufficient to know that the altered rhyolyte characterizes the upper portion of the series and is areally distributed in narrow belts.

The principal Clear Creek area lies southeast of the eastern Bragdon area, is elongated from northeast to southwest, has a length of about twenty-five miles and a width of six to twelve miles. The Sacramento river traverses it for over fifteen miles and Clear creek for more than twelve miles. Within the territory indicated, there are several later igneous masses as well as several isolated areas of Devonian strata. The latter are involved by the volcanic material in a way to indicate that they are older and apparently this Clear Creek area is based on Devonian strata largely. East of the McCloud river and south of Pit river, as Mr. Diller called to my attention, this same volcanic series rests on Upper Carboniferous strata. Numerous greenstone dikes occur in the Paleozoic strata and are evidently related to the volcanic series. East of the Carboniferous belt a thick sheet of the volcanic series dipping eastwardly as a whole, goes down under the Pit shales. From my own observation I state that the upper portion of the volcanic material, particularly the altered rhyolyte, alternates with the lower strata of typical Pit shales; in other words, the volcanic series grades into the Pit shales by inter-stratification showing that deposition of ordinary sediments began before the vulcanism ceased and also making it evident that there is no time interval represented between the two formations.

Because of the Pit shales being conformably overlain by abundantly fossiliferous Triassic limestone and also of their containing Triassic fossils in the valley of Pit river, they certainly are Triassic in age. The Clear Creek volcanic series occurring immediately under and conformable to the Pit shales is evidently also Triassic. That it is not Carboniferous is probable from the way it unconformably overlies both Devonian and Carboniferous. Very late Carboniferous, if not even Permian, as professor J. P. Smith suggested to me, is represented in the Paleozoic belt east of the McCloud river and this entire Carboniferous series, thousands of feet thick, must have been removed by erosion and the Middle Devonian rocks laid bare, before the first Clear Creek eruptions occurred. The non-conformity here indicated is the equivalent of that which in many places separates the Paleozoic from the Mesozoic rocks.

I am aware that volcanic material including tuff seems to be present in the Carboniferous east of the McCloud river as at Grizzly peak, about eight miles north of the Big Bend of Pit river, to which locality I was directed by Mr. Diller. I am also aware that volcanic material including tuff occurs in the Triassic and Jurassic strata east of the McCloud river and higher stratigraphically than the lower portion of the Pit shales, but I discriminate between these other occurrences and the definite early Triassic series which I call the Clear Creek formation. The latter I always treat as a stratigraphic unit because in Trinity and Siskiyou counties where I study chiefly, it has definite structural relations similar to a sedimentary series. I will define the Clear Creek series as consisting of the entire mass of volcanic material which, collectively considered, occurs in thick broad sheets unconformably overlying the Paleozoic rocks and passing conformably under the Pit shales.

(To be Continued.)

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Mineral Tables for the determination of minerals by their physical properties; by A. S. Eakle, New York. John Wiley & Sons. 8vo. Cloth. pp. 73, 1904. Price, $1.25.

This set of tables is arranged in form of an analytical key, first based on streak and color and secondly on hardness, and is calculated for use introductory to blowpipe analysis. It would be quite convenient in any mineralogical laboratory, and would help an amateur in his first efforts of observation of the outward characters of minerals. N. H. W.

Geographic Influences in American History; Albert Perry Brigham. 12mo. 366 pages. By mail, $1.40. Ginn & Company, Boston, 1903.

The author passes the United States in review both historically and geographically. Beginning with the colonial settlements in New England and the Atlantic border, the description and discussion swing round the southern Appalachians, along the gulf coast, up the Mississippi valley, over the states of the plains, the borders of the great lakes, crosses the mountains, descends to the Pacific and ends with the new states in the far northwest. In leaving each section the author vouchsafes some encouraging or warning, or prophetic words.

This review is entertaining and instructive; and for the youthful student of American history and civilization it mingles with the description of nature and the natural features of the country sufficient of the peculiarities that characterize the people of the sections and their industry to introduce into the history a flavor of story-telling; and this is so guided as to lead the reader, unwittingly perhaps, into a conviction not only of the powerful role of the geography of the country in our present, but of the greater destiny that awaits us in the future

The rhetorician might object to so many sentences beginning with the copulative "and." Even one paragraph (p. 290) opens with the same word.

The book is a cultivation of a new field in an original way, disclosing on the part of the author a perfect familiarity with all parts of the United States, socially, historically, commercially and physiographically. N. H. W.

New Physical Geography; Ralph S. Tarr. 12 mo. 457 pages. The Macmillan Company, New York. Price, $1.00. 1904.

This book is not intended to supersede the author's "Elementary Physical Geography," published a few years ago; it is rather a "new work, different in plan, in scope, and, in many respects, in subject matter." It is very fully illustrated, mainly by half-tone figures, as may be seen by the fact that, having 457 pages, its illustrations are numbered to 568.

While the book is devoted mainly to a description of the physical forces and their effects, in nature, thus being a treatise on geological phenomena, it also has, at the end, chapters devoted to the special physiography of the United States which describe the ways in which physiographic conditions have modified animal life or directed the progress of settlement and the industries of the various sections. Pages 298 to 394 are devoted to this phase of geography. Appendices are added which treat of the revolution of the earth, latitude and longitude, common minerals and rocks, the geological ages, tides, magnetism, meteorological instruments, weather maps, maps, laboratory equipment and field work. The whole constitutes an admirable illustrated epitome of dynamic geology and physiography and of the ways and means of intelligent observation. It is adapted for use in High Schools. N. H. W.

Gems and Gem Minerals; by OLIVER CUMMINGS FARRINGTON, Chicago, A. W. Mumford, 1903. $3.00.

It is, naturally, difficult to write anything new on the subject of gems, particularly when one is writing for the public and perhaps hampered by the stipulations of a publisher. In "Gems and Gem Minerals" Dr. Farrington has brought together concisely and in pleasing form much that is instructive and essential to a good understanding of the subject treated.

The book is a handsome quarto volume of some two hundred and odd pages, with sixteen full-page colored plates and sixty-one figures in the text. In it are discussed the nature and occurrence of gems, their meaning, physical properties, manner of cutting, and mounting. There are also chapters on imitation gems and how to detect them, on superstitions concerning gems, and birthstones. All these are hackneyed subjects, but are set forth in new dress and made available to the buyer of moderate means.

The latter two-thirds of the volume, pages 66 to 223, inclusive, to be more explicit, are taken up with systematic descriptions of the various gem minerals, both in their natural and cut conditions, their mode of occurrence, and the localities where found.

Few, perhaps, realize the extent to which gem mining is carried on in various parts of the United States. Perhaps still fewer realize how many minerals there are, of little value in themselves, which can be utilized to advantage for decorative purposes. Quite aside from the faceted stones, which owe their beauty largely to their high refractive qualities, there is a large series of minerals, including Amazon-stone, varieties of chalcedony, and even certain types of granitic rocks, which, when cut cabochon and properly mounted, can be made attractive as well as unique ornaments.

Aside from Tassin's Catalogue of the Gem Collection of the National Museum, this is the second treatise on the subject which is available and at all comprehensive. Kunz's "Gems and Precious Stones," the first edition of which appeared in 1890, is a much more elaborate treatise, and its colored plates, although fewer, are of higher grade; but this is what one should expect, when its price is taken into consideration. In Dr. Farrington's book we have an authoritative work within reach of the average book-buyer, and that is, in itself, sufficient excuse for its existence. G. P. M.

An attempt to classify Palaeozoic Batrachian Footprints; by G. F MATTHEW, LL.D. [Trans. Roy. Soc. Can., Ser. 2, vol. IX, Sec. IV, p. 109.] *New genera of Batrachian Footprints of the Carboniferous System in Eastern Cranada;* by the same author. [Can. Rec. Sci., vol IX, No. 2, p. 99, 1903.]

These two articles by Dr. Matthew are based chiefly on material in the Peter Redpath Museum of McGill University, the greater part of which had been obtained by the late Sir W. J. Dawson. The author remarks upon the broad use of generic names by various writers who have described the footprints of vertebrates on layers of the Carboniferous rocks of America, and attempts to classify them under some of the generic names that have been used.

A table is given showing the classification of these tracks, based on the number of toe-marks, and on their form. The impression made by the tail (or belly) is not found to be of value for generic separation, as closely allied forms may or may not exhibit such a mark. In the first article three plates of figures are given to show the types of the more important genera that have been described, chiefly by King, Lea, Butts, Marsh, Leidy, and Dawson.

In the second article are described a number of new genera, based chiefly on the material in the Redpath Museum. Most of these are small species that were found among the material that Sir William Dawson had collected at the Joggins shore in Nova Scotia from the Coal Measures that outcrop there. Two of the genera are based on larger forms that were sent to Sir William from other parts of Nova Scotia, and differ generically from any described forms.

The variety in these footmarks indicates animals of very diverse structure, and some from the Joggins may have belonged to genera of Microsaura from that locality, which Sir William has described in his "Airbreathers of the Coal Period." A plate of figures of the new genera accompanies the article.

Harriman Alaska Expedition, Volume III: Glaciers and Glaciation. By GROVE KARL GILBERT. Pages xii, 231; with 18 plates, and 106 figures in the text. New York: Doubleday, Page & Co., 1904.

The observations of Mr. Gilbert and others in this expedition in 1899, voyaging along all the southern coast of Alaska to Unalaska and Bogoslof islands, and thence northward to Plover bay on the Siberian coast, to the vicinity of Cape Prince of Wales, and to St. Lawrence island, are well narrated in this volume, with very ample illustrations from photographs of the glaciers and of the topographic features. The scope of the work is confined chiefly to these observations and the discussion of their significance as to the action of glaciers, past and present, without attempting a more comprehensive survey of all that is known concerning glaciation in Alaska.

No considerable descriptions of the Muir glacier, which has been elaborately and usefully studied, nor of the Malaspina ice-sheet and other very interesting piedemont glaciers of the country, are therefore given. which must be sought elsewhere in the writings of Muir, Wright, Russell, Reid, Cushing and others. Nor is the northwestern border of the continental Pleistocene ice-sheet and glacial drift sketched or discussed; although the exemption of the greater part of Alaska from that wide glaciation of nearly all of the northern half of North America is one of its most remarkable problems, doubtless closely connected with the difficult questions of the causes of the Glacial period.

Much attention is bestowed upon "hanging valleys" and their testimony for deep valley erosion by glaciers. Their occurrence along the fiords, and at the sides of the deep fiordlike passages (used as steamboat routes) which divide the mainland of southeast Alaska and British Columbia from its cordon of mountainous islands, is regarded as proof that the erosion beneath the debouchures of the tributary hanging valleys was effected by the deeper and more rapidly flowing ice in the central fiord valleys. This view leads the author to conclude that the land generally was not greatly uplifted before and during the Ice age, or, at least, that the great depths of the fiords cannot be accepted as a demonstration and approximate measure of pre-Glacial land elevation.

W. U.

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CORRESPONDENCE.

DR. KARL A. VON ZITTEL. It is with great sorrow that I have learned of the death of my friend and employer Dr. Karl A. von Zittel of the Paleontological Museum of Munich. I had the high honor to be his collector in the fossil fields of Kansas and Texas for five seasons, and our relations were such that I shall always respect and honor his memory. As I dearly love the animals of the past and have devoted my life to making collections of them, I ought to understand the heart of that great German, and I can say from personal experience of him, that I never knew a man who filled my ideal of what a paleontologist should be, as did Dr. Zittel. Absolutely unselfish, and giving the collector his just dues under all conditions, honoring me by giving full credit for my discoveries, and calling attention to all Americans that entered his museum, that these Texas and Kansas specimens so beautifully mounted there, were collected by myself, a citizen of the U. S. It is not egotism, but to show the generous characer of Zittel that I copy from some of his letters in 1901, when I was so fortunate as to secure a fine collection of Permian vertebrates, from Baylor county, Texas.

'*Munich, Feb. 5th. Charles Sternberg. My dear Sir* : You have probably received the interesting paper on *Eyrops megacephalus* by my assistant Dr. Broili: and will see that we have begun work on your Texas collection of 1895. The whole material has now been prepared for scientific description, but unfortunately for the reptiles, particularly for the genera *Dimetrodon* and *Naosaurus,* the material is still too fragmentary even for a partial description of these interesting forms, as it has always been my opinion that the publishing of poorly founded genera and species was more detrimental than beneficial to science. I also wish to enlarge our *Amphibian* material. However, so much of real worth is contained in this collection from the Permian beds of Texas, that I have always wanted to augment it and complete it. Unfortunately, up to the present time I have been unable to obtain the necessary money for the renewal of exploration; however, I am happy to say that I am in position to set something aside for Permian collection, 'and for Texas I naturally turn to you to ask if you would care to collect for our museum again this spring."

Then followed a business proposition that I could not accept. He however met my wishes in a letter dated Munich, March 17th, 1901.

"I am sorry that from your letter of the 25th of February last, you do not consider yourself to be in a position to work for the Munich Museum in Texas this spring. I can readily understand that after your long activity in scientific fields, without material results, you are somewhat discouraged and embittered, and feel that your services in this direction have not been sufficiently appreciated. For my part, I have done my best to give you credit for the scientific side of your work, and your collections from Kansas and Texas in the Munich Museum will always be, as I wrote you, an everlasting memorial to the name of Charles Sternberg."

After making a proposition agreed to, the Doctor in a letter of December 23, 1901, thrilled me, by the good news:

"The five boxes with your great collection, as well as the express box with the little skulls, have arrived safely. I have looked over the results of your researches and think that the collection of this year is better than any other made before in Texas. With few exceptions we have nearly all the genera created by Prof. Cope and several in better condition. Besides there are certainly a good number of very interesting and new material which will give us business for several years. I am very glad that I can give you such a favorable report about your hard work, in the interests of this museum. I hope for further friendly relations with yourself. With the best wishes for the coming year and the kindest regards,

Faithfully yours,

DR. V. ZITTEL.

So from the standpoint of a collector who has worked so many years in the barren fossil fields of America in the interests of paleontology, I can say the truest lover of the ancient life of the earth I ever knew has gone to his rest. God ever keep his memory green wherever his works on paleontology shall go. CHARLES H. STERNBERG.

PLEISTOCENE FORAMINIFERA FROM PANAMA. The several species of Foraminifera heré listed were obtained from material dredged in digging the Panama canal. It was contained in a large specimen of gastropod shell—Aquillus (Septa) tritonis *Linn*. var. nobilis *conrad*. The shell was dredged up near Mindi, five kilometers from the Atlantic coast. The material consisted largely of the "brownish dirty colored sand" described by Hill (Geology of the Isthmus of Panama: Bull. Mus. Comp. Zool., vol. 28, no. 5, p. 174, 1898). The material there is described as Pleistocene and it certainly must be late Pleistocene at that. for the colors on the shell in which the material was found were very well preserved. The species of Foraminifera found are all living ones, almost without exception now in the gulf of Mexico. The nearest localities mentioned by Flint (Report of the U. S. National Museum for 1897, pp. 249 et seq.) are given for comparisons. The species determined are as follows:

1.—*Haplophragmium calcareum?* Brady.

But one specimen found and that poorly preserved. Noted by Flint from the straits of Yucatan.

2.—*Bulimina inflata* Seguenza.

The typical form figured by Brady and by Flint. Noted by Flint from the gulf of Mexico.

3.—*Bolivina plicata*. D'Orb.

The specimens tend somewhat toward *B. aenarensis* Costa. The latter species is found in the gulf of Mexico. Frequent.

4—*Miliolina angularis* Flint.

This is evidently the species described by Flint from the straits of Yucatan. Frequent.

5.—*Miliolina seminulum* Linn.

Very common. Also found living in the gulf of Mexico.

6.—*Miliolina venusta* Karrer.

The specimens have the keels and are in every way like this species although it is given by Brady as a deep water form. However Flint records it from the west coast of Patagonia and gulf of Tokyo in 194 and 9 fathoms respectively.

7.—*Miliolina oblonga* D'Orb.

Several specimens evidently this species. Living forms reported from the northeastern coast of So. America.

8.—*Peneraplis pertusus* Förskal.

Only one specimen found but that excellently preserved. Reported by Flint from straits of Yucatatn.

9.—*Orbitolites marginalis* Lam'k.

One very perfect specimen found and numerous fragments. Reported from Florida by Flint.

10.—*Uvigerina angulosa* Williamson.

Frequent. Reported on the west coast by Flint.

11.—*Sagrina striata* Schwager.

One specimen only. Flint does not report this species but the Challenger dredged it off the So. American coast.

12.—*Truncatulina wuellerstorfi* Schwager.

Frequent. Reported from the gulf of Mexico by Flint.

13.—*Anomalina coronata* Parker and Jones.

Rare. Reported by Flint off the coast of Georgia.

14.—*Nonionema scapha* Fichtel and Moll.

Frequent. Reported from Panama bay and the coast of Yucatan by Flint.

Boston Society of Natural History. JOSEPH A. CUSHMAN.

NEW YORK ACADEMY OF SCIENCES. The Section of Geology and Mineralogy held its regular meeting January 18, 1904, with the chairman, professor James F. Kemp, presiding. In the absence of the secretary, Dr. A. A. Julien was appointed secretary *pro tem,* and papers were presented by Dr. Irving and Mr. Wilson, abstracts of which follow:

"Microscopic Structure and Origin of Certain Stylolitic Structures in Limestone," by J. D. Irving. From an extended examination of stylolitic limestones collected in Indiana and Wyoming, mainly by Mr. M. L. Fuller and himself, the author has drawn the following conclusions regarding the origin of the peculiar structures:

1. They were initiated along a thin layer in limestone and have been produced by the interpenetration of the limestone material on either side of this clay seam.

2. They are entirely independent of the presence of fossils existing in the rock, for they occur equally in those portions of the rock where fossils are absent and where they are present.

3. They were not formed by metamorphic agencies, or by the weight of overlying strata, or by other causes which would tend to distort and crush the rock material.

4. They were produced by a cause which operated on the material of the rock while it was yet unconsolidated, and in a condition approximating that which obtained at the time of deposition.

5. They originated under great pressure, the rock material being sufficiently soft to allow the bending of individual stylolites, and yet potentially rigid so that organisms were sharply sheared off while held in the soft matrix.

While the cause of the pressure and the manner in which it had operated to produce these structures have not been determined, the author suggests that their production may be the result of the hydrostatic pressure of the sea water lying above the deposits. In the instances examined stylolites are characteristic of marine deposits formed in water varying from 400 to 2500 fathoms in depth. If sea water be taken to have an average specific gravity of 1.028, then a one-foot column of water exerts a hydraulic pressure of .434 lb. per sq. in. of area. This would give, for the depth stated, a hydrostatic pressure of from 1041 to 6408 lbs. per sq. in. Such a pressure as this, coupled with the soft unconsolidated nature of the rock at the time it might have been exerted, seems to fulfill better than any other the conditions demanded by the observed facts.

"Recent Journeys Among Localities Noted for the Discovery of Remains of Prehistoric Man," by J. Howard Wilson. The author discussed man in the earliest times before the neolithic age and afterwards illustrated his paper by nearly forty views of some of the most famous rock shelters, caves and deposits of Europe which have furnished remains of palæolithic man, including also slides of the type implements and weapons from which is derived the principal evidence of man's existence in Quaternary times.

The paper recited briefly the history of the subject, the first finds, especially the work of Boucher de Perthes, and the gradual development of the science of prehistoric archæology. Reference was made to some of the disputed evidence of man's existence in the Tertiary period, and then the subject of man's undoubted existence as early as the Second Glacial period was treated more at length, with a consideration of the climate and physical conditions which prevailed in Palæolithic times.

The paper closed with an attempt at a realization of the great antiquity of palæolothic man as shown by the immense physical and geological changes which have taken place since he first made his undoubted appearance.

At the regular meeting, February 15, vice-president James F. Kemp presiding, the secretary read a letter from Dr. J. G. Aguilera correcting a statement in one of the papers presented at the December meeting of the Academy, as reported in *Science,* regarding the great Bacubirito meteorite of Mexico. Dr. Aguilera called attention to the fact that this meteorite was discovered in July, 1871, as was stated by A. del Castillo in *Catalogue descriptif des Meteorites,* Paris, 1889. It was described by F. Sosa y Avila in *Minero Mexicano* in 1890, and afterward was visited by Signor Buelna as a commissioner of the Geological Institute of Mexico for the purpose of calculating the cost of transporting it to the city of Mexico. In connection with this expedition Buelna made several drawings and photographs of the great mass of iron. Through the Geological Institute professor H. A. Ward received exact information as to the locality of the meteorite and then visited it, removing the earth from about it and making new photographs. Professor Ward's recent articles (1903) have drawn renewed attention to this enormous meteoric mass, but the credit of original discovery and description belongs to the Mexicans.

The program of the evening comprised two papers, abstracts of which follow:

"The Occlusion of Igneous Rock within Metamorphic Schists," by Dr. Alexis A. Julien. The term "inclusive" is commonly applied by the petrographer to ordinary dikes of igneous rock, surrounded by beds of sedimentary rocks or of crystalline schists, intersecting them or intervening between their foliation planes. But for similar masses cut loose from all connections with the underlying magmatic source, swallowed up within strata of crystalline schists, and experiencing all stages in the process of reaction and final absorption, during metamorphic change, another term seems to be called for, "occlusion," signifying shut or sealed up beyond escape. Although the word is borrowed from the physicist, this can produce no confusion when applied to petrographic phenomena. Occluded igneous rocks may belong to either the acid or basic class, as illustrated respectively, on Manhattan island, by the earlier intrusions of pegmatyte, never found as intersecting dikes, and by the intercalated sheets of dioryte-schist. Occlusion is usually attended by mechanical and chemical processes. The former consist of thinning or thickening of igneous masses caught between the folia of schists, during orogenic movements, into lenticular masses; the crumbling and corrugation of sheets, and even rolling into cylinders; and the forcing of the pasty masses along foliation planes, in the form of intercalated or "secondary" dikes. The chemical processes usually consist of micaceous alteration and ultimate absorption by disintegration and dissemination through the surrounding country rock. .

In discussing this paper, professor Kemp spoke of the value of the interpretation to those who have studied the region.

"Outlines of the Continents in Tertiary Times," by Dr. W. D. Matthew. The author presented a series of world-maps showing the hypothetical outlines of the continents during the Pleistocene, Pliocene, Miocene, Oligocene, later Eocene and at the opening of the Tertiary period, as contrasted with the modern conditions. The series was gotten up for use in the hall of fossil mammals in the American Museum of Natural History, to illustrate the geological distribution of different groups of mammals during the successive epochs of the Tertiary and Quaternary. It is intended to represent a somewhat conservative view of past changes in world geography, and is regarded as a working hypothesis, based on our present knowledge of geology, palæontology and zoology, especial consideration being given to the mammalian palæontology.

The former extension of the Antarctic continent, so as to join Australia with South America, is regarded as occurring at the end of the Cretaceous period and is represented in the first map of the series. The connection with South Africa is regarded as too problematic to place on the map. The Eocene map shows the extreme of Tertiary submergence of the continents, which are represented as forming six isolated land masses. The three northern continents are connected throughout the Oligocene, Miocene, Pliocene and Pleistocene, Africa being joined to them by the Miocene, South American by the Pliocene epoch. The Pleistocene map shows especially the simultaneous glaciation of both northern and southern regions, modified in the north by sinking of the old Arctic continent beneath the sea-level.

The supposed ancient continents of Lemuria, Atlantis, the Brazil-African land bridge, etc., are regarded either as proposed on insufficient data or outside the limits of this series.

In general it has been found possible to consider the true ocean basins (limited by the 1000-foot contour) as permanent through Tertiary time. The union of Antarctica with Australia and South America is an exception to this rule, but is based on a large amount of evidence. It appears probable also that the disturbed belt which stretches through central Europe to south-central Asia, and ends perhaps in the East Indian islands, has been, in part, raised from abyssal depths to an equally stupendous hight above the sea, since the beginning of the Tertiary.

Discussion.—Professor Osborn empnasized the value of these maps as expressing working hypotheses for the use of students of vertebrate palæontology.

Dr. Julien called attention to the evidences of glaciation in South Africa as having a bearing upon the question of a previous existence of land masses further south.

EDMUND OTIS HOVEY, *Secretary.*

PERSONAL AND SCIENTIFIC NEWS.

THE KENTUCKY GEOLOGICAL SURVEY has been revived. The Legislature has appropriated $15,000 dollars per year for two years. C. J. Norwood will act as director, with a corps of assistant geologists.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of February 24th the following program was presented: "The study of minerals in the laboratory," Arthur L. Day; "Oil fields of Alaska," George C. Martin. At the meeting of March 9th the following program was presented: "The occurrence of extra morainic pebbles in Western Pennsylvania," Lester H. Woolsey; "Fossil floras of the Yukon," Frank H. Knowlton; "Glacial erosion in western New York," Marius R. Campbell.

E. J. CHAPMAN, for many years professor of mineralogy and geology at Toronto University, died recently at Hampton, England. He was born in Kent, England, February 21, 1821, and in his early years followed a military career, serving in the foreign legion of the French army in the Algerian campaign. He afterwards studied engineering in England under I. K. Brunel, and some years later was appointed to the chair of mineralogy in University College, London. In 1853 he accepted the new chair of mineralogy and geology in University College, Toronto, a position which he held until 1896 when he returned to England, having inherited an estate.

UNITED STATES GEOLOGICAL SURVEY.

Collection of fossil plants from the Yukon coal areas of Alaska made in 1902 by Arthur J. Collier and in 1903 by Arthur Hollick have been examined by F. H. Knowlton, who, in a preliminary report, states that these fossils are of both Tertiary and Cretaceous age. This find of Cretaceous fossils in some of the coal bearing rocks of Alaska is an important and interesting discovery. At present it seems that the coal on the Yukon above Ramport is of Tertiary age, while that below Ramport is Cretaceous.

Recent experiments by Heinrich Ries on the effect of tannin in clays are of importance. The experiments proved conclusively that the addition of either tannin or straw emulsion to the clay diminishes the amount of water necessary for tempering the clay; that it causes a decrease in the air shrinkage, as there is less water to evaporate from the clay; that the total shrinkage after burning is consequently less in most cases; that the increase in the tensile strength of the clay is very remarkable; that the air cracking is greatly diminished, even in the worst clays; that the hardness of the treated clay, both in the green condition and in the burned material, is such that it is capable of scratching the untreated clay; and that the plastic feeling of the clays tested is greatly enhanced.

The Iola (Kansas) quadrangle is among the topographic maps recently issued.

The only expedition which has crossed central Alaska from the Yukon to the Arctic ocean was undertaken by F. C. Schrader and W. J. Peters in 1901. An account of this expedition will soon be published as Professional Paper No. 20, under the title of "A reconnaissance in northern Alaska."

Among the folios of the Geologic Atlas recently issued are the following: Indiana (Pennsylvania), No. 102; Nampa (Idaho), No. 103; Silver City (Idaho), No. 104.

The results of topographic work in Texas in the region of the big bend of the Rio Grande are shown on the following quadrangles: Polvo, Terlingua, Terlingua Special, Chiso, and an unnamed quadrangle. The first three are ready for distribution. The district covered by these maps is of interest because of the Terlingua quicksilver deposits, recent finds of cinnabar, marked box canyons and peculiar topographic features.

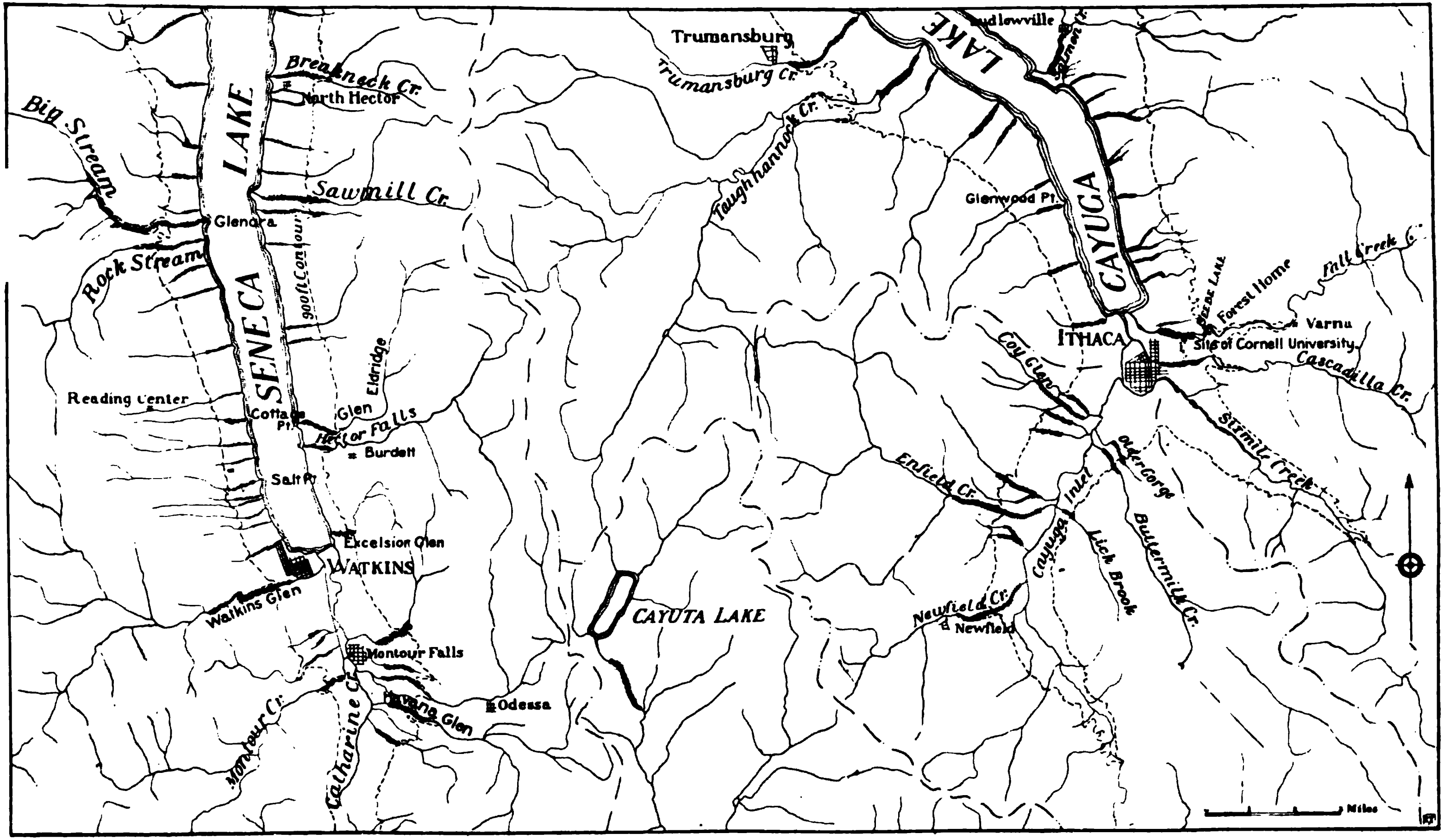

FIG. 1. Sketch Map of the Southern Ends of the Cayuga and Seneca Valleys.

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HANGING VALLEYS IN THE FINGER LAKE REGION OF CENTRAL NEW YORK.*

By RALPH S. TARR, Cornell University, Ithaca, N. Y.

PLATES XI—XV.

Reason for this Paper: Ten years ago I published a paper† stating evidence that seemed to me to prove an origin by glacial erosion for the basin occupied by Lake Cayuga. Two years earlier Dr. Lincoln had published the same conclusion.‡ It is in these two papers, so far as I know, that the first distinct use was made of hanging valleys in interpretation of glacial erosion, although the name hanging valley was not then used.

During the ten years that have elapsed since the publication of my first paper I have been obtaining facts bearing upon the physiographic problems presented in the Finger Lake region. Among these facts are a number which oppose the interpretation first placed on the phenomena. It had been my intention not to publish these facts until it was possible to definitely settle the questions raised; but the recent revival of the glacial erosion theory§ made it seem to me desirable to state these facts in order that other workers might have them for use in further consideration of the physiography of the Finger Lake region. The immediate reason for this paper, however, is the publica-

* Published by permission of the Director of the U. S. Geological Survey. I wish to acknowledge my indebtedness to my colleague Prof. A. C. Gill with whom I have frequently discussed the question of the origin of Cayuga valley, and from whose stand in opposition to the glacial erosion theory I have in no small degree been led to consider, and reconsider, alternate hypotheses even when their reconsideration seemed to me needless.

† Lake Cayuga a Rock Basin, *Bull. Geol. Soc. Amer.*, vol. v, 1894, pp. 339-356. A full bibliography of the region up to 1894 appears in this paper.

‡ *Amer. Jour. Sci.*, vol. xliv, 1892, pp. 290-301.

§ Papers presented by DRYER and by CAMPBELL before the St. Louis meeting of the Geological Society of America.

tion of an editorial criticism of Mr. Frank Carney's paper by professor Fairchild* in which it is evident that the cause for the criticism is the failure on the part of professor Fairchild to recognize some of these facts, with which, however, Mr. Carney was familiar.

Upland Valleys: The upland valleys of the Finger Lake plateau region are mature in form; but there are numerous evidences of rejuvenation, especially in the presence of steepened valley walls, now on one side, now on the other. The region of the present divide between the mature upland valleys of the Oswego and Susquehanna drainage systems is far more rugged than the upland to the north; but by reason of drainage changes this rugged divide is, in a number of cases, crossed by streams from north of the divide. It is one of these, Fall creek, that Mr. Carney described in the article† criticised by professor Fairchild. Some of these stream diversions are apparently due to causes related to the ice invasion; others have earlier date and may have relation to land tilting and headwater erosion. A glance at a map made by combining the topographic sheets of the region is sufficient to show a marked southward trend to valleys now tributary to the north-flowing main valleys of the Finger lakes,—for example Salmon and Fall creeks, tributary to Cayuga valley; several small tributaries to Seneca valley; and the two arms of Keuka and Canandaigua lakes, to mention only a few of the many instances.

It would be possible to offer hypotheses to account for these and other phenomena presented by the upland valleys, and several working hypotheses are being followed in the field work; but since the facts at present at hand are not sufficient to verify any one hypothesis, little of profit would result from their statement. Suffice it to say, therefore, that the drainage history of the Finger Lake region has been complex and is still unsolved.

Hanging Tributary Valleys: Where these upland valleys approach the main valleys now occupied by Cayuga and Seneca lakes they are hanging well above the bottoms of the main valleys. This may be illustrated by Fall creek, to which

* AMER. GEOL., vol. xxxiii, 1904, pp. 43-45.

† *Journal of School Geography*, vol. ii, 1903, pp. 115-124.

FIG. 4.—Triphammer Falls in the Post-Glacial Gorge of Fall Creek, Ithaca.

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FIG. 6.--Looking down the Post-Glacial Gorge of Fall Creek. The Crest of Ithaca Falls (seen in Figure 5) is seen just below the dam in the Gorge.

FIG. 6.—Looking down the Post-Glacial Gorge of Fall Creek. The Crest of Ithaca Falls (seen in Figure 5) is seen just below the dam in the Gorge.

professor Fairchild calls especial attention. With its headwaters removed by possible glacial diversion* this stream now rises in the moraine south of Cortland and flows through a deeply drift-filled valley, without reaching rock, to a point between the villages of Varna and Forest Home, where it encounters rock at an elevation of 880 feet. Below this point it is in rock most of the way until it emerges on the Ithaca delta; but below Forest Home (Fig. 1) it crosses a buried gorge (Figs. 3 and 7) in which Cornell University has formed a lake, Beebe lake, from which the University water supply is obtained. The fall (Triphammer, Fig. 4), over which the creek emerges from this buried gorge, furnishes the power used for lighting the University buildings, and also supplies the hydraulic laboratory.

Where Fall Creek gorge forms the northern boundary of the Cornell University campus, rock may be traced for a distance of a mile or more, both north and south of the creek, with such practical continuity as to eliminate the possibility of the existence of any other than a gorge valley. The level at which the rock may be thus traced is about at the 800-foot contour. Consequently, the bottom of a valley emptying into Cayuga lake valley along this line must of necessity be at least 800 feet above sea level. Translating these figures with relation to the main Cayuga valley, the tributary valley bottom must be at least 420 feet above the surface of Cayuga lake, and at least 845 feet above the present rock floor of the lake valley (Fig 7). The last conclusion is based upon the fact that a boring in the Ithaca delta, almost opposite the point where Fall creek flows out upon this delta, reached rock at a depth of 430 feet. Although this boring is near the middle of the valley, it by no means follows that it is made at the deepest point. In fact, if the Cayuga valley is a stream-cut gorge, there is ample opportunity for a much greater depth on the eastern side of the boring.

In other words, if a valley tributary to Cayuga valley existed along the line of the present Fall creek, its bottom is now hanging at least 845 feet above the bottom of the main valley to which it was a tributary. This difference in elevation

* CARNEY. *Jour. School Geog.*, vol. ii, 1903, pp. 115-124.

exists in a distance of a little over a mile. It is, however, highly probable that the real bottom of this hanging valley is still higher; but without borings to show the exact rock contours in the moraine-covered region above Beebe lake, the actual elevation of the hanging valley bottom cannot be determined. All that is certain is that its bottom cannot be lower than the 800 foot contour.

Therefore, the present Fall creek occupies a valley in which there are three very different parts: (1) a distinctly mature upper part; (2) a post-Glacial gorge where it descends the hill slope from the edge of the hanging valley; and (3) a buried gorge section. In the first, or upper portion, down to Forest Home, the valley walls are moderately sloping, indicating maturity. The exact elevation of the bottom of this part of the valley cannot now be determined, for, throughout most of its extent, the stream flows in thick drift deposits. Nor is it possible to determine the form or slope of the valley bottom. This mature valley broadens and flattens out as it nears the Cayuga valley, and at Forest Home suddenly changes in character, for a large part of the remaining distance the stream flowing in a post-Glacial gorge, with exceedingly steep slope (Figs. 4-7), to approximately the level of Cayuga lake. In one case, at Beebe lake, the gorge is interrupted, and the valley broadens, where the stream cuts diagonally across a drift-filled gorge. This buried gorge is much wider than the distinctly post-Glacial gorge.

This set of conditions is illustrated in figures 2-7. Figure 7 is a profile along Fall creek, showing the gentle slope of the upper mature portion, and the abrupt change in slope where the stream passes beyond the edge of the hanging valley.

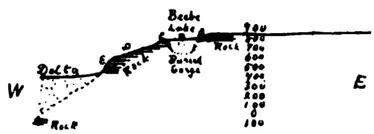

Fig. 7. Profile of Fall creek which descends the Cayuga valley slope along the northern boundary of the Cornell University campus. (Horizontal scale, ½ inch to mile; vertical scale, ½ inch to 1000 feet. Column of figures gives elevations in feet with reference to sea level.)

It also shows the location of the buried gorge. Figure 2 looks toward the northeastern wall of the buried gorge (A, Fig. 7), and shows Fall creek emerging from a post-Glacial gorge cut in the north wall of the buried valley. The upper rock surface represents the approximate bottom of the hanging valley. Figure 3 is a view from near the same point as figure 2, but looking in the opposite direction (westward). The broad flat (B, Fig. 7), now transformed to a lake by a dam where the steam is rising, is the site of the buried gorge which Fall creek crosses diagonally. The dam is in a post-Glacial gorge where Fall creek once more enters the rock, this time on the southwestern wall of the buried gorge. The site of this dam (now enlarged) is seen in figure 4, which also shows the post-Glacial gorge and waterfall (C, Fig. 7). These three pictures illustrate the contrast in the valley form of the post-Glacial and the buried gorge sections.

From C to the delta (Fig. 7), the stream tumbles through a gorge, descending 300 feet or more in less than a mile. Figure 5 looks from the west into Lower Fall creek gorge, the fall being at the point E in figure 7. Cornell University stands approximately on the 800 foot contour line, near the point where the slope of the valley wall changes (Figure 16). It is on the edge of a hanging valley, occupied on the right by

Fig. 8. Profile of Cascadilla creek, which descends the valley side at Ithaca, on the southern boundary of Cornell University campus. (Same scale as Fig. 7.)

Fall creek, on the left by Cascadilla creek (Fig. 8), which comes down the hill slope to the right of the right hand tower (Fig. 5). Between these two creeks, as well as north and south of them, practically continuous rock is traced, eliminating the possibility of a buried valley, other than a gorge. Figure 6, taken from the bridge back of the fall (Fig. 5; at D Fig. 7), and looking westward across the delta toward the point where figure 5 was taken, gives an idea of the slope below the hanging valley, down which Fall creek descends.

Were this the only instance of its kind, it might be assumed that Fall creek valley is not a real hanging valley but that, as professor Fairchild suggests,* it may represent drain-

* Amer. Geol., vol. xxxiii, 1904, p. 44.

age in another direction. As a matter of fact, Fall creek is only one of a score of similar hanging valleys. Buttermilk

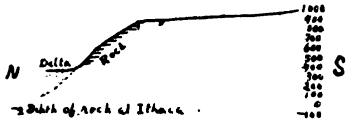

Fig. 9. Profile of Buttermilk creek (Ten Mile creek on U. S. G. S. Dryden sheet), two miles south of Ithaca. (Scale same as Fig. 7.)

creek (Fig. 9), south of Ithaca, likewise approaches the edge of the Cayuga valley wall in a broad, mature valley, then, at about the 900 foot contour, tumbles over the valley wall in a post-Glacial gorge. Here, too, there is a drift-filled gorge of earlier date. Practically continuous rock, eliminating all but gorge valleys, can be traced at the 800-900 foot level. This valley is therefore hanging at least 945 feet above the rock floor of Cayuga valley at Ithaca, two and a half miles distant. Lick brook, (Fig. 10), a short distance farther south, shows the same condition.

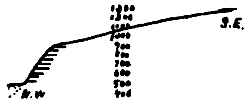

Fig. 10. Profile of Lick brook, four miles south of Ithaca. (Scale same as Fig. 7.)

Newfield creek, on the west side of Cayuga valley, presents the same phenomenon, its hanging valley floor at Newfield being over 950 feet above the rock bottom of the main valley at Ithaca. Coy Glen, just to the north, is in a hanging valley over 950 feet above the main Cayuga valley; and the valleys of

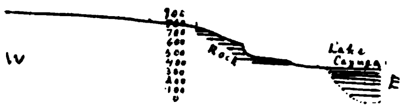

Fig. 11. Profile of Taughannock creek (Taghanic on U. S. G. S. Genoa sheet), eight miles northwest of Ithaca. (Scale same as Fig. 7.)

Taughannock (Fig. 11) and Trumansburg creeks hang at least 845 feet above the rock bottom at Ithaca, and also above the deepest point (435 feet) in Cayuga lake, seven or eight miles distant.

Fig. 12. Profile of Montour creek, Seneca valley, two and one-half miles south of Watkins. (Same scale as Fig. 7.)

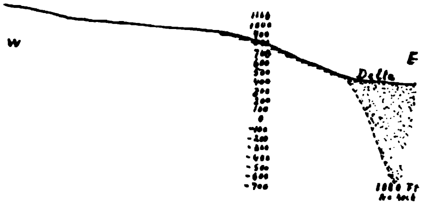

Fig. 13. Profile along Watkins Glen, in Seneca valley. (Same scale as Fig. 7.)

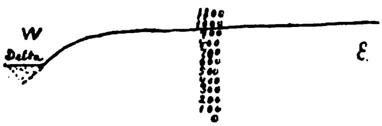

Fig. 14. Profile of Havana Glen creek, Seneca valley, three miles south of Watkins. (Same scale as Fig. 7.)

In the Seneca valley, Montour creek (Fig. 12), Watkins creek (Fig. 13), and Big and Rock streams, on the west side, each hang at about 1500 feet above the deepest known point in the Seneca valley, which is 1080 feet;* and the Odessa (Fig. 14) and Burdett valleys (Figs. 15 and 22), on the east side, are also hanging about 1500 feet above the deepest point in the main valley.

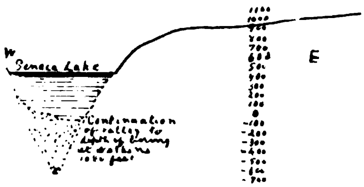

Fig. 15. Profile of Hector Falls creek, Seneca valley, two and one-half miles north of Watkins. (Same scale as Fig. 7)

It is to be understood that these figures are only approximate, and subject to correction whenever borings may reveal the actual rock floors of these valleys. That the tributary valleys are hanging, and hanging several hundred feet above present lake level, in both Cayuga and Seneca valleys, is beyond question. In each of the valleys selected the rock has been traced at least as high up as the level mentioned with such continuity as to exclude the possibility of a broad, mature, drift-filled valley. In each case, too, it is probable that the real bottom of the hanging valley is higher than the figures

* The deepest point in Seneca lake is 618 feet; but at Watkins, near the middle of the valley, a boring of 1080 feet failed to reach the bottom of the drift.

given. But in each case there is a buried gorge in the bottom of the mature hanging valley. Other valleys tributary to both Cayuga and Seneca lakes have similar conditions.

From this evidence it is held that the testimony of a large number of valleys establishes the fact that there are, in both Cayuga and Seneca valleys, hanging tributary valleys of mature form whose rock bottoms, leaving out of consideration gorges sunk in them as a result of some rejuvenation, are at least 845 and 1500 feet respectively above the rock floor of the main valleys to which they are tributary.

Steepened Main Valley Slopes: One of the most striking features in the topography of the Cayuga and Seneca valleys is the change in slope of the valley walls at about the 800 or 900 foot contour. This is shown not only along but between the tributaries. It is especially apparent in the field, and is clearly revealed on the contour maps. Above these contours the slopes are prevailingly moderate; below, they are decidedly steeper, as the accompanying cross-sections (Figs. 16-23) clear-

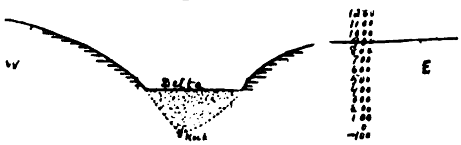

Fig. 16. Cross section of Cayuga valley at Ithaca, crossing Cornell University campus. (Scale same as Fig. 7.)

ly show. This is not always the case, for in some instances while the change in slope is noticed on one side of the valley it is absent on the other side. This is illustrated in the cross-sections (Figs. 16 and 17). Moreover, there are places where the steep valley wall extends well above the 900 foot contour.

Fig. 17. Cross section of Cayuga valley just south of Lick brook, four miles south of Ithaca. (Scale same as Fig. 7.)

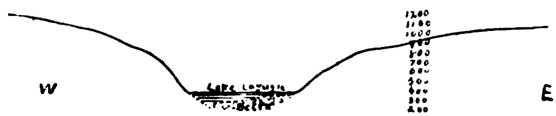

Fig. 18. Cross section of Lake Cayuga valley, two miles north of Ithaca. (Scale same as Fig. 7.)

The cross-sections of the Cayuga and Seneca valleys (Figs. 15, 16, and 19-23) indicate that the steepened lower slopes extend below lake level, giving to both valleys the gorge form. That the lower hillside slopes are decidedly different from the upper ones is indicated not only by the profiles, but also by the fact that below the line separating the two slopes there are numerous pronounced cliffs, while above this level there is an almost complete absence of cliffs. The cliffs occur on both sides of each main valley, and are sometimes traceable for long distances, in some instances for more than a quarter of a mile. In some cases roads descending this lower slope are deflected by cliffs, and it has even been necessary to cut a bench in the rock. This is especially noticeable along the roads leading out of Watkins. Once the steepened slope is passed, however, the roads extend upward along an easier grade and rarely encounter rock.

Fig. 19. Cross section of Cayuga valley, just south of Taughannock creek, eight miles northwest of Ithaca. (Scale same as Fig. 7.)

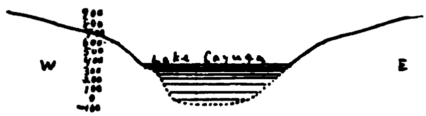

Fig. 20. Cross section of lake Cayuga valley, one mile north of Trumansburg creek, ten miles northwest of Ithaca. (Scale same as Fig. 7.)

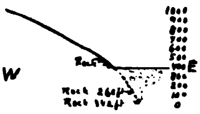

Fig. 21. Profile of west side of Cayuga valley at site of artesian wells in the southern outskirts of Ithaca. (Scale same as Fig. 7.)

A second fact of importance, therefore, is that at about the level where the streams of the upland hanging valleys change from a moderate slope to descend with steep grade

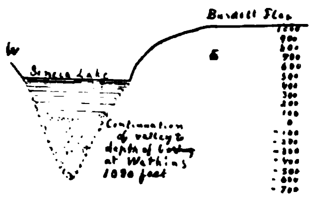

Fig. 22. Cross section of Seneca lake valley opposite Burdett, two and one-half miles north of Watkins. (Scale same as Fig. 7.)

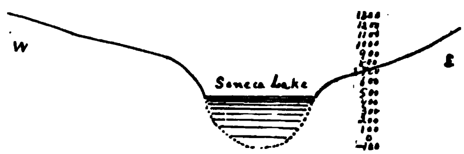

Fig. 23. Cross section of Seneca lake three miles north of Watkins. (Scale same as Fig. 7.)

through gorges to the main valleys, there is very generally a notable change in the slope of the main valley walls. This change in slope is usually near the 800-900 foot contours. The fact that this change, though general, is not universal is undoubtedly significant.

The Buried Gorges: None of the large tributary valleys so far studied, and few of the smaller ones which enter the southern half of the Seneca and Cayuga valleys, are without evidence of the existence of gorges which antedate the last advance of the ice. In some cases these earlier gorges descend the steepened valley slope along a path entirely apart from that followed by the post-Glacial gorges. This condition is illustrated by Watkins glen, where the stream follows approximately the same course as the earlier gorge up to the edge of the steepened slope, then, just above the point where the railroad bridge crosses the upper part of the glen, turns to the south and follows a post-Glacial gorge to the town of Watkins. It is also illustrated by Buttermilk creek, which likewise has approximately the same course as the buried gorge up to the edge of the steepened slope, then turns southward and descends to the Cayuga valley through a post-Glacial gorge. In the case of Buttermilk creek the earlier gorge, much broader than the post-Glacial gorge, causes a decided sag in the hillslope, in which both walls of the moraine-filled gorge are in places shown (older gorge Fig. J.)

In other cases the streams follow the approximate course of the buried gorges clear down to the main valley. Six Mile creek illustrates this condition. This stream alternately enters the buried gorge, forming broad amphitheatres, and where it for a short time leaves the earlier gorge, crosses spurs of rock in narrow post-Glacial gorges.

A third condition is where a stream enters the earlier gorge, clears out part or all of its drift-filling, and follows it across the steepened slope to the main valley. This is certainly the case in lower Six Mile creek; it also seems to be the case in Taughannock and in Fall creek. Since the complication of post-Glacial erosion obscures the evidence, it is not always as easy to prove this condition as it is in the case of Six Mile creek, where the evidence is clear and convincing. But it is a fact that streams of approximately the same volume, in approximately the same kind of rock, often have quite different lower courses. In many cases, where the buried gorge is distinctly to one side, we have a chance to measure the amount of post-Glacial cutting. Thus, Buttermilk creek falls into the Cayuga valley over a step-fall fully 100 feet high, almost flush with the steepened main valley slope; the same condition is illustrated in many streams entering Seneca lake. Taughannock fall, on the other hand, is three-quarters of a mile from the lake, from which it is separated by a broad gorge between 200 and 300 feet deep. To account for the difference in these gorges it seems necessary, in the case of the larger gorges, like Taughannock, to appeal to excavation during the period of earlier gorge cutting.

Where it emerges from the steepened main valley slope, the earlier gorge of Buttermilk creek has rock almost entirely across its mouth at approximately the 440 foot contour, or 485 feet above the rock floor under Ithaca, two miles distant. With about the same degree of continuity, rock may be traced across the earlier Fall creek gorge, and far to the north and south of it. While in these cases the rock is not traceable continuously, its continuity is such as to eliminate the possibility of the existence of a gorge of the width of the buried gorges. In the case of Taughannock, rock may be traced at lake level without a break. On both the east and west shores of Seneca lake, rock may be traced continuously for miles, absolutely eliminating the possibility of the existence of gorges entering the lake valley below lake level. This is much more clearly shown on the west than on the east side, for on the west side there is a continuous rock cliff from Watkins to Rock stream, and farther.

This evidence establishes a third point regarding the drainage history of Seneca and Cayuga valleys, namely that there is an almost, if not absolutely, uniform condition of gorges in the bottoms of the mature hanging tributary valleys; that these gorges, being drift-filled, antedate the last ice advance; that they are broader and deeper, hence required longer time to form than the post-Glacial gorges; and that, where they enter the main valleys, their rock bottoms are above lake level.* They therefore resemble hanging valleys, since their bottoms are in some cases, as Taughannock, about 400 feet above the main valley bottom one-half mile distant. Since we have no data proving what their bottom slope actually is, though it seems evident that their slope is very steep, and possibly great enough to carry them down to the main valley axis, it may not be proper to consider them hanging valleys. If the interpretation of hanging valleys is warranted, which I doubt, then the tributary valleys to Seneca and Cayuga lakes are double hanging valleys,—an upper mature hanging valley and a lower hanging gorge valley.

The Post-Glacial Gorges: Incidentally, in the above discussion, the main facts of the relation of the post-Glacial gorges to the condition of hanging valleys and buried gorges have been stated. The rare beauty of the gorges and falls of the Finger Lake region, indicated by the wide reputation of Watkins Glen, which is but one of many, is a result of this relation. The great number of gorges and waterfalls, and their wide reputation, warrant a specific restatement of their cause.

Coming to the edge of the steepened slope of the main valleys, after a fairly quiet course, along a moderate grade in the mature hanging tributary valleys, the water finds itself forced to tumble down the steepened slope either to the valley floor or to lake level. Hundreds of streams, large and small, have this condition thrust upon them. With cutting power accelerated by the increased slope, the streams have set to work on their task with excellent result. They have cut deeply into the shale strata, and here and there have crossed the buried gorges, revealing their presence by the sudden broadening of the valley wherever a stream moves from its post-Glacial gorge in shale to one of the drift-filled buried valleys

* While a large mass of data has been gathered bearing on the buried gorge problem, the work has not progressed far enough to warrant an attempt to discuss it here, excepting in so far as it has a bearing on the question in hand.

(Figs. 2-4). Locally these broadened portions of the valleys have been called amphitheatres. In those cases where the post-Glacial streams have followed older gorges for a considerable distance, as in the case of Six Mile creek, the gorge valley is decidedly broader than in the distinctly post-Glacial sections.

The influence of the older gorges, the effect of alternating layers of shale and sandstone of varying hardness, and the influence of joint planes, account for the wonderful variety of form in the gorges of this vicinity and the varied beauty of the numerous waterfalls. A more detailed consideration of this phase of the drainage problem of central New York will be undertaken in another paper.

The Theory of Glacial Erosion: Since the publication of Lincoln's paper,* and of my own on lake Cayuga,† the theory of glacial erosion has been held as the most rational explanation of the phenomena in the Finger Lake region. The upper mature hanging valleys were not then fully recognized; but the glacial erosion theory was nevertheless based upon the fact that distinctly mature valleys, descending toward the two Finger lakes, were rock-enclosed at their bottoms at an elevation above present lake level. Though the existence of older gorges had been determined in one or two cases, their abundance and their relation to the mature hanging valleys were not understood.

If the hanging valleys of the Finger lake region may be taken as evidence of glacial erosion, the amount of this erosion is prodigious. From the evidence of a number of valleys, as well as from that of the steepened lower slopes of the main valleys, the edge of the hanging valleys nearest the axis of the main valleys may be placed at not less than the 800 foot contour. This edge is, in a number of instances, less than one mile from the axis of the main valley. The hanging valleys have such maturity of form that a moderate grade may confidently be assumed for their bottom slope, eliminating, of course, the gorges later cut in their bottoms. Continuing this grade onward beyond the present edge of the hanging valleys would not carry their bottoms greatly below the level of the 800

* *Amer. Jour. Sci.*, vol. xliv, 1892, pp. 290-301.

† *Bull. Geol. Soc. Amer.*, vol. v, 1894, pp. 339-356.

foot contour. It seems safe to entirely ignore the effect of their extension to the main valley axes, since it is certainly far less than the probable error in locating the exact level of the hanging valley bottoms. Since Cayuga lake bottom lies at least 50 feet, and Seneca valley bottom at least 640 feet below sea level, the amount of glacial erosion indicated is at least 850 feet in the case of Cayuga and 1400-1500 feet in the case of Seneca valley. This is far in excess of the estimate previously made, and in the case of Cayuga lake it takes no account of the filling in the lake bottom, which must be considerable. If the hanging valleys are taken as evidence there can be no escape from the conclusion that there has been this great amount of glacial erosion.

A modification of the glacial erosion theory has been advanced during the progress of the investigation of the problem, and is still being considered. It is as follows:— During its first advance the ice deeply eroded the valleys; during interglacial conditions the older gorges were cut; with return of glaciation the valleys were deepened still further. During as many glaciations as this region experienced this process was continued. On this basis the older gorges are interglacial; their cause is the lowering of their baselevel by the overdeepening of the valleys to which they were tributary. Since facts sufficient to establish or to overthrow this explanation are not yet at hand, it must stand at present merely as a working hypothesis.

Facts Opposed to the Glacial Erosion Theory: With the progress of this investigation facts have appeared which make the glacial erosion theory increasingly difficult to accept; and I have found myself seriously doubting the explanation which formerly seemed to me established.

DISCORDANCE OF TRIBUTARIES: One opposing fact is the discordance of the tributary valleys. While the vast majority are hanging at a nearly uniform level, some lack this characteristic. The two best instances of discordance are Six Mile

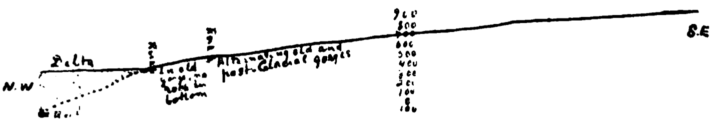

Fig. 24. Profile of Six Mile creek, entering the Cayuga valley at Ithaca. (Scale same as Fig. 7.)

and Salmon creeks, both tributaries to the Cayuga valley from the east. In the case of Six Mile creek (Fig. 24) there is a change in slope several miles from its mouth; but this change occurs much farther back than in the other valleys, and it is not nearly so distinct. It is true that the present stream follows approximately the line of the buried gorge, and this fact may account for its discordance. Salmon creek (Fig. 25)

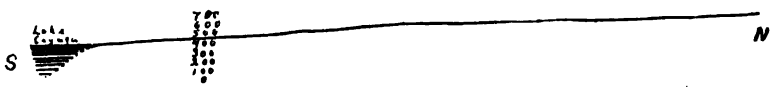

Fig. 25. Profile of Salmon creek, entering Cayuga lake six miles north of Ithaca. (Scale same as Fig. 7.)

shows no change of slope throughout its course, and is altogether out of harmony with the other streams tributary to the southern ends of Cayuga and Seneca lakes. It is significant that this is a north-south valley, and, on the glacial erosion theory, its discordance might be explained as a result of glacial erosion.

Little progress in solving the problem of the significance of this discordance seems possible until the grade of the gorges can be established; and boring appears to be the only way of accomplishing this result. At present, therefore, it must suffice to point out the fact of discordance and to show that, while out of harmony with the other valleys, the discordance may possibly be so explained as to fall in with the glacial erosion theory. But this discordance gains importance as evidence against glacial erosion when supported by other opposing evidence.

Gorge Form of Valleys: The cross section of both Cayuga and Seneca valleys is opposed to the glacial erosion theory. Below the 800 foot contour the slope is gorge-like. If the depth is due to glacial erosion, trenches from one to two miles wide, and at least 850 feet deep in the case of Cayuga and 1400-1500 feet in Seneca, have been cut in the bottoms of broad, mature valleys. It does not seem probable that ice could so concentrate its work in a narrow zone along the axis of a winding valley The valley form below the 800 foot contour is rather that of a gorge formed by river cutting. It resembles the valley of the Susquehanna further south, in the formation of which ice erosion certainly had no important effect.

PRESENCE OF ANGULAR CLIFFS: In such a deep, narrow valley it would seem as if ice motion would be so interfered with by friction on the sides as to lose rather than gain erosive power. The presence of cliffs, sometimes with moraine banked up against the angular joint plane corners, points toward the accuracy of this conclusion. These cliffs occur in places where post-Glacial stream erosion is altogether out of the question. It is certainly a point difficult to explain that actual precipices, with angular joint plane corners, should form part of the wall of a valley due to ice erosion. River-deepening would cause just such rock outlines; but ice erosion should leave rounded, smoothed surfaces. The presence of these cliffs is considered to be a very important evidence against the glacial erosion theory.

PRESENCE OF PRODUCTS OF RESIDUAL DECAY: That ice erosion can hardly be appealed to in explanation of the Cayuga valley is strongly indicated by the presence, in at least two places, of evidence of pre-Glacial decay. One of these places is in the gypsum quarries between Union Springs and Cayuga, near the northern end of the lake. Here is still preserved the irregular surface of pure gypsum, with decayed material above, overlain by till. The other locality is at the Portland Cement Works, about five miles north of Ithaca on the east side of the lake, where Tully limestone is being removed for making cement. The upper Tully layer is ice-smoothed on the top and covered with a thin veneer of till; but beneath it, and separating it from the next layer below, is a red clay of residual decay. It seems evident, therefore, that ice erosion was unable to wear down beneath the zone of rock decay. This locality is well below the edge of the hanging valleys, and in a part of the lake valley where ice erosion must have been as vigorous as in most portions.

PRESENCE OF A CAVE: In this same limestone, near by, there is a small cave which must have been formed after the valley was lowered enough to permit the free passage of ground water. Post-Glacial time seems too short for this; if inter-Glacial, later ice erosion should have removed it. The presence of this cave seems to testify to pre-Glacial deepening of the main valley, and to oppose the glacial erosion theory.

PRESENCE OF AN ISLAND IN LAKE CAYUGA: Rising above the surface of lake Cayuga at Union Springs is an island of limestone rock. How this could have been preserved while the valley was being so markedly deepened by ice erosion has always been difficult for me to understand, even when ice erosion seemed the only explanation of the valley depth. It may properly be arrayed with the other evidences opposing the ice erosion theory.

DIRECTION OF ICE MOTION: To accomplish the vast amount of work postulated by the glacial erosion theory, the ice must have worked under exceptionally favorable conditions, and for a long time. As a matter of fact the Cayuga and Seneca valleys lie transverse to the direction in which the ice moved at all times excepting when the ice sheet was so thin as to be transformed at its margin to lobes guided in movement by the larger valleys. The distribution of moraines in the Finger Lake valleys proves that during its closing stage the ice attained this condition. The striae which were made during this period extend in the direction of the valleys and were earlier interpreted to represent the general ice movement as well.

Whatever marked valley-deepening the glacier accomplished in these valleys must have been done in those periods of ice advance or retreat when the valleys were occupied by lobes. That the lobes remained in these valleys for some time, during the waning stages of the last ice advance, is proved by the marked development of moraines. It is also proved by the fact that, while north of the moraines of these valley lobes the glacier in most places scoured away the clays of residual decay, south of the valley moraines residual clays are exceedingly abundant, appearing in scores of places.*

The facts stated in the last two paragraphs, while not directly opposed to the ice erosion theory, tend to weaken it. For they show (1) that the glacier accomplished little work of erosion during its advance over the region which lies south of the massive moraines that occupy the valleys at the heads of the Finger lakes, having been incompetent to remove the rock below the zone of decay; (2) that during this time, and

* The evidence of this, as well as the nature of the moraines of this region, will be presented in the discussion of the Pleistocene geology of the Watkins Glen folio, now in preparation.

even later, the ice crossed rather than followed the Cayuga and Seneca valleys; and (3) that the valley deepening could have been accomplished only when the ice was thin enough to be deflected in the form of valley lobes by the valleys that extended transverse to its general motion. This limits the length of time for effective ice erosion, and also the depth, and hence efficiency, of the ice tool. Instead of having the entire period of glacial occupation, and the maximum depth of ice, for the deepening of these valleys, the erosive work, if glacial, must have been accomplished by relatively thin ice operating for only a part of the period of glaciation.

Absence of Sufficient Glacial Drift: A point that has on several occasions been urged against the glacial erosion theory is that the materials eroded are not in evidence in corresponding deposits. This has never appealed to me as a vital point, though now that it is evident that the ice erosion must have been accomplished mainly when the glacier margin was north of the divide of the Finger Lake valleys, and hence that the materials eroded from these basins must have been largely laid down within the confines of these valleys, it becomes a more effective argument against the ice erosion theory. The morainic deposits in the Cayuga valley, for instance, are totally inadequate to refill the basin, or even to make more than a mere beginning; and these deposits include a goodly percentage of materials from beyond the limits of the Cayuga valley.

But even with this limitation, the point is not a strong one against ice erosion. There is no way of determining how much of the material eroded from the basins was carried beyond the divide as till, clay, and overwash sand and gravels. Nor are we in possession of facts which tell us how extensive were the deposits made when the glacier advanced, as it doubtless did, in lobes along these valleys. Moreover, possible earlier ice advances may have left deposits, later swept away. I should consider the argument that there is lack of evidence of accumulated materials the weakest of all that have been advanced in opposition to the ice erosion theory for these valleys.

Summary of Facts Opposed: In summary it may be said that the evidences against the ice erosion theory are as follows:—(1) The fact that, while most of the tributaries are in hanging valleys, there is a discordance, especially well marked in two cases, both of which, however, may possibly be explained in harmony with the glacial erosion theory; (2) the supposed ice-eroded valleys have the cross-section of gorges; (3) the presence of many angular, precipitous cliffs in the zone of supposed ice erosion below the hanging valley level; (4) the presence, in two places, of evidences of preglacial decay, in situations where such vigorous ice erosion as is postulated should have removed them; (5) the presence of a cavern in similar position; (6) the existence of an island in lake Cayuga in the line of glacial erosion; (7) the fact that the ice erosion could have been accomplished only during those periods when the ice was thin enough to be deflected from its main course by the valleys which lie transverse to the main ice movement, thus limiting ice erosion in time, and to those periods when its depth, and hence effectiveness, was diminished. The argument that sufficient material to refill the basins is not in evidence is not considered of great weight.

An Alternate Hypothesis: Throughout this investigation an effort has been made to consider all alternate hypotheses that could be suggested, and all but one of these are easily eliminated. It scarcely seems worth the while to take the space to consider three of these hypotheses, which, though advanced for, and possibly applicable to other regions, are centainly not the explanation of condititons here. Reference is made to (1) faulting, (2) folding, and (3) the occupation of the lateral hanging valleys by glaciers while the main valleys were being deepened by running water. Evidence is clear that there is no extensive faulting or folding in this region, and that there are no gathering grounds for valley glaciers and, indeed, positive evidence that no such glaciers existed. It is doubtful if anyone will call for the proof of these assertions, which could easily be substantiated.

A fourth hypothesis, however, that of rejuvenation, has not been so easy to set aside, and the difficulty of eliminating it has been greatly increased by the recognition of the wide distribution of the older gorges, which has been accomplished since the publication of my earlier paper on the origin of the Lake Cayuga basin. While this hypothesis long seemed improbable, the necessity of considering it has increased with the accumulation of evidence opposed to the glacial erosion theory.

Stated in general terms this hypothesis is as follows:—the region of the Finger lakes, having attained a condition of topographic maturity, represented by the hanging valleys, and by the gentle slopes of the main walls above the 800 foot contour, was subjected to rejuvenation. The main valleys, with their elevation above sea level decidedly increased, and the power of their streams possibly further increased by tilting, were transformed, below the 800 foot contour, to broad, deep gorges, whose bottoms were cut to levels below present sea level. The side valleys, always behind the main valleys in stage of development, were, moreover, occupied by smaller and weaker streams, which, in the majority of cases were either only slightly or even adversely affected by the tilting. These weaker members of the stream systems were unable to do more than cut the gorges which are so generally present in the bottoms of the hanging valleys. On this theory a moderate amount of glacial erosion is of course allowed, possibly deepening the valleys somewhat, and certainly broadening them by erosion on the sides, and, in favorable situations, even partially erasing the older gorges.

If the tilting were from the northeast it might account for the discordance of Salmon creek. If it were accompanied by headwater erosion and stream capture near the present divide, it would account for many peculiar conditions of drainage in that region.

Further studies are necessary to settle this problem. The glacial erosion theory is opposed by various facts; the rejuvenation theory must at present be considered a possible explanation of the phenomena. Distinct progress toward solution might be made if it were possible to establish the grades of the buried gorges. If they can be shown to have such steep grades as to carry them down to the main valley bottoms the theory of rejuvenation will be greatly strengthened. To gain this proof it seems necessary to have a series of borings, since the older gorges are deeply drift-filled.

If rejuvenation by uplift is the explanation of the conditions in the Finger Lake valleys it is but a part of a wider interference with drainage. Studies now in progress outside the basins of the Finger lakes have discovered certain evdences indicating rejuvenation; but these studies have not progressed far enough to warrant a discussion of them. In fact the present paper, leaving the solution of the main problem unsettled, would not have been written had it not seemed important to present, for the use of other workers in the field, the facts which seem opposed to glacial erosion, and the reasons for believing that rejuvenation by uplift cannot be ignored as a possible explanation of the conditions in the Finger Lake region. The statement of my conviction that the glacial erosion theory cannot be accepted as proved, seems especially important in view of the fact that in my earlier paper, overlooking some of the evidence, I published the conclusion that the Lake Cayuga valley owes its great depth to ice erosion. Until the facts opposing glacial erosion are explained, or until the possibility of the rejuvenation theory is eliminated, the current theory for the origin of these valleys by glacial erosion, recently revived, cannot be considered established.

THE TYPICAL SPECIES AND GENERIC CHARACTERS OF AVICULIPECTEN, McCOY.*

By George H. Girty.

Within the past few months I have had occasion to examine into the status of McCoy's genus *Aviculipecten,* and as the name was found to have been subjected to a variety of usage, it seemd that the record of my inquiry and some of the circumstances connected with it might be of more than personal interest.

McCoy defined this genus in 1851,† naming no type but givi g an illustrative figure and describing two new species, *A. planiradiatus* and *A. ruthveni.* The original diagnosis and structural figure may be quoted as follows:

Inequivalve, more or less inequilateral, straight, or slightly extended obliquely towards the posterior side; anterior ear flattened, smaller than the posterior, sharpiy and deeply defined, with a deep notch in the right valve between it and the body of the shell for the passage of the byssus; posterior ear slightly pointed, extending about as far as the

* Published by permission of the Director of the U. S. Geological Survey.

† *Ann. Mag. Nat. Hist.*. 2nd ser., vol. vii, p. 171.

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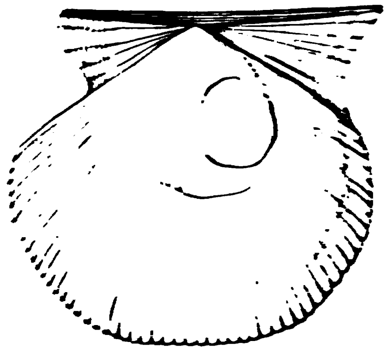


[illegible] Cast of [illegible] after McCoy

As McCoy failed to designate a type species for [illegible] the [illegible] would be to assume for that function [illegible]. This seems, however, to have been [illegible] in no instance. Woodward writing in 1854* three years after McCoy's genus was published, states that the type of [illegible] is *Pecten* [illegible] Sowerby, [illegible] was taken instead of [illegible], which I think is really the genotype, has not been ascertained. The same type species is

* *Man. of the Mollusca*, London, pt. 2, 1854, p. 262.

assumed in the later editions of Woodward's manual, as, for instance, the fourth published in 1880 (p. 417).

Many authors in discussing the genus do not mention its typical species, but several, chiefly those for whom Zittel's Handbook served as a basis, illustrate *Aviculipecten* by figures of *A. papyraceus* Sowerby. While in the German edition of 1885 Zittel figures *A. papyraceus* in this manner he mentions *A. docens* and *A. concavus* as representative forms, without, however, designating them as the genotypes. With this exception Miller, in his North American Geology and Paleontology, seems to be the only one who has used *A. docens* as the type of *Aviculipecten,* and though the decision upon this point can not be made with assurance, I believe that his course is the proper one, although possibly the species should bear a different name.

As will be seen by a reference to McCoy's description, which I have quoted above, the recognition of the genus was due to observations made upon a fine suite of fossils from Lowick, Northumberland, one of which presumably formed the basis for the structural figure which accompanies the diagnosis. Logically the species to which the Lowick specimens belonged, a key to which is afforded by the illustration and locality, should be taken as the type of the genus. It is unfortunate, however, that McCoy did not furnish an identification of this form at the time *Aviculipecten* was proposed.

It is evident that neither *A. planiradiatus,* described from the Carboniferous limestone of Derbyshire, nor *A. ruthveni,* a single small specimen of which was found at Lowick, can be the form upon which McCoy's observations were made. Four years later (in 1855), in British Paleozoic Rocks and Fossils, McCoy had occasion to treat the species of this genus at some length. The generic diagnosis and remarks (p. 392) are quoted verbatim from the original reference. The species of *Aviculipecten* are described in two places, the Devonian ones with the other Devonian forms and the Carboniferous with the Carboniferous. Their arrangement is alphabetic. *A. docens,* the sixth in sequence among the Carboniferous species, said to be common in the dark Carboniferous limestone of Lowick, Northumberland; one of the figures is obviously a wash drawing of the same specimen of which a sketch accompanied the first generic diagnosis; and finally the statement is made in so many words that it was this species which taught the author the generic difference from *Pecten,* hence the name. It is absolutely certain, therefore, that *A. docens* was the form upon which the genus *Aviculipecten* was based. Were it not for a fact to be mentioned later, an objection might here be raised against employing this species as the genotype, on the ground that a generic name proposed must be associated with some typical species, while *A. docens* was not published until four years after the description of *Aviculipecten.* It might be urged, on the other hand, that as *A. planiradiatus* and *A. ruthveni* are unquestionably not the species upon which *Aviculipecten* was really based, neither of them can with any propriety be made the type; that the genus being without a type at the time of its proposeal is invalid until the description of *A. docens* in 1855 placed it upon a proper footing, and that it can be regarded as only then having been properly established. Such an academic argument, however, is not necessary, for from the synonymy preceding the specific description and the remarks following it, it is clear that *A. docens* is not a species newly described, but a new name substituted for *Pecten flexuosus* which was published by McCoy in 1844, the name having been preoccupied by *Pecten flexuosus* Lamarck. Thus the discrimination of the species upon which the genus *Aviculipecten* was based dates from 1844, and antedates the generic description by seven years. As to the name of this type species, since *Pecten flexuosus* Lamarck is a living form, and certainly not an *Aviculipecten,* it does not conflict with *Aviculipcten flexuosus* McCoy, except so far as one adheres to the dictum "once a synonym always a synonym." While for my own part I am disposed to retain the older name *flexuosus,* others doubtless will use *docens* for the species, which has a clear right to be regarded as the type of the genus *Aviculipecten.* The discrimination of the typical, however, among the several species used by different writers is of little practical importance in the present case, because all are so similar in general appearance as to establish the probability that they are congeneric, and it may have been merely a different conception of the synonymic relations of these species which led Woodward, usually very precise in these matters, to speak of *A. granosus* as the genotype. In any event, the standing and affinity of *Aviculipecten* must be determined from the characters of *A. flexuosus.*

The generic characters of *Aviculipecten* as observed in the species last mentioned are set forth in the extract already quoted from McCoy. Although the ligament is described by him as being confined to a narow facet along the hinge margin without a median cartilage pit, Eastman's Zittel speaks of it quite differently, for in that work the ligament is said to lie in numerous shallow grooves radiating to the amphidetic margin of the area. This characterization seems to date back to Woodward (in 1854), who describes the hinge area as flat, with several long, narrow cartilage furrows, slightly oblique, on each side of the umbones. From these diagnoses of the genus, that of M'cCoy and that of Woodward, two distinct lines of descent derive, according as one or the other is referred to. I am not aware that the genus has ever been redescribed upon the basis of later studies of *A. flexuosus,* or on the other hand, that it has been redefined from *A. granasus* Sowerby, the species designated by Woodward as the genotype. The fact that Woodward assumes a different species for the type than either of those accompanying the first descriptions, and assigns characters different from those observed by McCoy, furnishes some ground for suspicion that two genera are really involved; but I am indisposed to entertain that view. The descriptions agree in most particulars and especially in stating that *Aviculipecten* is without the median resilium of *Pecten,* while if the narrow facet along the hinge margin of McCoy's description were striated, a character which might vary in distinctness with different individuals, the words of Woodward would also seem to apply. It appears to me rather more probable that the differences indicated by the two diagnoses are to be connected with differences in the observer, but especially with differences in the material observed, both specific differences and those due to unlike or unequal preservation.

The spelling Aviculipecten is here adopted, and seems to be the only one which is etymologically correct, though doubtless those who adhere without deviation to original spellings would prefer to retain the old form. The component names are both Latin words, and according to the almost universal rule of composition in that language the connecting vowel *i* should be used. The same construction holds in the case of *Aviculipinna, Pernipecten,* etc.

Following the definition given by Woodward in the first and subsequent editions are Tryon (1882), De Koninck (Faune du Calcaire Canbonifère de la Belgique, iii, cnq. part, 1885, p. 210), Fischer (1887), Zittel (Grundzüge, 1895), Zittel (1900). Following the definition given by McCoy in the original and subsequent works are Zittel (1881-5), Hoernes (1884), Nicholson (1889), and Steinmann and Doederlein (1890). Miller (1889) includes in his definition of *Aviculipecten* both types of structure, and in this I suspect he is probably right. These works are for the most part compilations. I have been able to find very few discussions of the genus based upon actual observation of characters, a circumstance doubtless due to the rarity with which these shells are so preserved as to show the characters of hinge and interior.

It was manifestly impossible to examine more than a comparatively small number of the works in which this genus is discussed, the majority of those referred to being textbooks. Some of the different points of usage are shown by the following statement: McCoy (Ann. and Mag. Nat. Hist., vol. 7, 1851, p. 171) names no type and gives an anonymous structural figure which proves to belong to *Aviculipecten docens; A. flexuosus* Woodward (Man. Mollusca, pt. 2, 1854, p. 262—also in later editions—) gives no figures and designates *Pecten granosus* Sowerby as the type; Zittel (Handbuck der Palaeontologie, abth. 1, vol. 2, 1881-5, p. 31) figures *A. papyraceus* and cites as examples *A. docens* McCoy and *A. concavus* McCoy; Hoernes (Elemente der Palaeontologie, 1884) designates no type, but figures *A. papyraceus* Sow.; Tryon (Structural and Systematic Conchology, vol. 3, 1884, p. 291) mentions and figures *A. granosus* as if the genotype, Fischer (Man. de Conchyliologie, 1887, p. 947) figures *A. papyraceous,* and cites as an example *A. granosus* Sow.; Nicholson (Manual of Palæontology, vol. 1, 1889, p. 701) designates no type, and reproduces McCoy's original anonymous structural figure; Miller (North American Geology and Paleontology, 1889, p. 465) gives no figures and cites as the type *A. docens;* Steinman and Döderlein (Elemente der Palæontologie, 1890, p. 282) figure no representative of the genus and cite only *A. papyraceus* Sow.; Zittel (Grundzüge der Palæontologie, 1895, p. 261) cites no type, or other representation, but figures *A. papyraceus;* Zittel (Textbook of Palæontology, vol. 1, 1900, p. 380) mentions no type, but illustrates the genus by a figure of *A. papyraceus.*

ON THE GENUS RHYNCHOPORA, KING, WITH NOTICE OF A NEW SPECIES.

By D. K. Greger, Fulton, Missouri.

The punctate, rhynchonelloid genus, *Rhynchopora,* King (1) is represented in European faunas of Carboniferous and Permian age by a limited number of species, of which the typical form, *R. geinitziana* de Verneuil (2) is the most prolific. This species was originally described from the Permian of Russia and the labors of Prof. Tschernyschew and Dr. Stuckenberg have added two more species to the genus, also from that country, viz.; *R. nikitini* Tschernyschew (3) and *R. variabilis* Stuckenberg (4).

With the species enumerated above may be associated the *R. youngi* Davidson (5) from the Upper Carboniferous of Great Britain and the *R. theobaldi* Waagen (6) from the Salt range of India.

But a single species, *Rhynchopora pustulosa* White (7) has been identified, heretofore, in the faunas of the American Carboniferous. With this species and the two forms described in the present paper, the genus is shown to have as great a range of specific development in this country as in Europe.

Quite recently while making sections for microscopic study, we had occasion to cut a specimen of *Rhynchonella illinoisensis* Worthen (8) a shell with a pronouncedly fibrous external structure, and we were not a little surprised to find the internal laminæ of the shell highly punctate.

Upon this discovery a careful examination of all the "Rhynchonellas" in our possession, from the American Carboniferous, was instituted, which resulted in finding an additional representative of the genus, from the upper beds of the Burlington limestone.

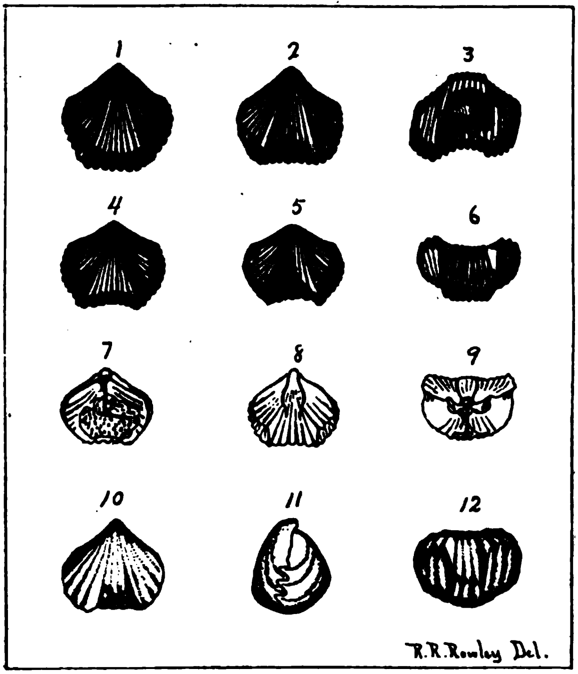
Rhynchopora beecheri, (sp. nov.)

Form and Outline of Shell: Sub-trigonal ovate, length and breadth about equal in neanic and ephebic specimens, with a tendency to become transverse and somewhat gibbous in gerontic individuals. Beaks obtusely pointed.

Pedicle valve: Depressed convex or nearly flat, with the mesial sinus well defined, beginning somewhat posterior to the transverse axis and becoming quite pronounced and turning abruptly upward in front. Anterior and lateral edges of the valve notched or serrate.

Brachial valve: Moderately convex, with a tendency to somewhat greater convexity in gerontic specimens. Mesial fold beginning about the middle of the valve and becoming very distinct in front. Margin of valve serrate as in the corresponding member.

Character of surface markings: Surface of each valve covered with from twelve to twenty-eight low, rounded plications which are well developed around the anterio-lateral edges but obsolete or wanting over the umbonal regions. From four to eight plications occupy the sinus and an equal number on the fold, while from six to ten cover each lateral portion of the valves. The space between the plications narrow and angular.



Explanation of Figures.

Rhynchopora illinoisensis (Worthen).

Fig. 1, brachial view, fig. 2, pedicle view, fig. 3, anterior view.

Rhynchopora beecheri, sp. nov.

Fig. 4, brachial view, fig. 5, pedicle view, fig. 6, anterior view. A typical example of the species.

Fig. 7, brachial view, fig. 8, pedicle view, fig. 9, posterior view. Internal cast from the chert, showing structural features.

Rhynchopora pustulosa (White).

Fig. 10, pedicle view, fig. 11, lateral view, fig. 12, anterior view. After Weller, for comparison.

Shell structure: Under a lens of moderate power the internal laminæ are shown to be highly punctate while the superficial layer is impunctate and apparently fibrous. Internal casts from the chert beds present a densely papillose appearance.

Measurements: Average dimensions of fifteen mature examples from our collection give the following, —Length, 12 mm.; breadth, 15 mm.; thickness, 10 mm.; width of sinus, at front, 8 mm.; width of plications, 0.6 mm.

Geological position: Upper Burlington limestone, from the white crystalline stratum and intercalary masses of chert, in association with—

Athyris incrassata Hall.
Athyris lamellosa L'Eveille.
Camarophoria ringens Swallow.
Cyrtina burlingtonensis Rowley.
Derbyia keokuk Hall.
Nucleospira obesa Rowley.
Productus alternatus Norwood and Pratten.
Productus burlingtonensis Hall.
Productus cora d'Orbigny.
Productus punctatus Martin.
Productus semireticulatus Martin.
Reticularia lineatoides Swallow.
Rhipidomella burlingtonensis Hall.
Rhipidomella thiemii White.
Schizophoria swallowi Hall.
Seminula ambigua Phillips.
Spirifer forbesi Hall.
Spirifer logani Hall.
Spirifer rostellatus Hall.
Syringothyris? plenus Hall.

Locality: Three miles east of Fulton, Missouri. Greger collection number 983.

Our collection contains specimens of this shell on which the plications are but feebly developed on the anterior margin with the length and breadth equal and not exceeding 6 mm. This species is dedicated to the late Dr. C. E. Beecher of Yale University.

Rhynchopora illinoisensis (Worthen.)

The original description of Prof. Worthen's species is here reproduced with some slight amendatory remarks.

"Shell of about medium size, transversely ovate to subcircular, wider than long, front nearly straight in the middle, beaks obtusely pointed. Ventral *(Pedicle)* valve slightly elevated near the beak and depressed towards the front into a broad, shallow mesial sinus, which is occupied by eight *(six to ten)* sub-angular plications that interlock in front with those of the opposite valve. There are also from eight to ten *(six to twelve)* similar plications on each side of the sinus. Dorsal *(Brachial)* valve sharply depressed at the sides, nearly flat from the beak to the front, which is elevated into a broad mesial fold on which there are about eight *(five to eleven)* elevated plications that interlock with those of the opposite valve and about the same number on each side of the mesial fold."

Shell structure: The internal laminæ of the shell are highly punctate, with the superficial layer fibrous impunctate.

Measurements: The average dimensions of ten examples of this species in our collection are as follows—Length, 13 mm.; breadth, 16 mm.; thickness, 12 mm.; width of sinus, at front, 9 mm.; width of plications, 0.7 mm.

So far as we are aware, this species has been found only at the locality that yielded the type specimens; In the Coal Measures, near Peoria, Peoria County, Illinois. Illinois State Museum, No. 2537. Greger collection No. 1009.

With our present knowledge, the following species can, with certainty, be referred to the genus *Rhynchopora*.—

Rhynchopora geinitziana de Verneuil.
Rhynchopora nikitini Tschernyschew.
Rhynchopora variabilis Stuckenberg.
Rhynchopora youngi Davidson.
Rhynchopora theobaldi Waagen.
Rhynchopora pustulosa White.
Rhynchopora illinoisensis Worthen.
Rhynchopora beecheri, sp. nov.

The internal structural features exemplified in a series of casts of *R. pustulosa* and *R. beecheri* and in sections of *R. illinoisensis* evince no characters at variance with the genus *Camarotoechia*. In the brachial valve a well developed median septum extends somewhat forward of the transverse line and in the pedicle valve the dental plates are high, prominent and correspond with the median septum in their forward extension. Consequently the taxonomic value of the genus as now understood rests wholly upon the punctate structure of the shell

References.

(1) King, W.—Ann. and Mag. of Nat. His^ 2nd. Ser., Vol. XVII. p. 596, pl. XII, figs. 7-11.

(2) De Verneuil, E.—Géol. de la Russ. et des Mont. de l'Oural. p. 83, pl. X, figs. 5 a-b.

(3) Tschernyschew, Th.—Der Permische Kalkstein in Gouv. Kostoma. p. 295, pl. XVIII, figs. 34-36.

(4) Stuckenberg, A.—Memoires du Comitè Gèologique de Russ. Vol. XVI, No. 1, p. 228, pl. III, figs. 13-14.

(5) Davidson, T.—British Carboniferous Brachiopoda, Supplement. p. 286, pl. XXXIII, figs. 11 a-c.

(6) Waagen, W.—Paleontologica Indica, Salt Range Brachiopoda. p. 425, pl. XXXIV, fig. 1.

(7) White, C. A.—Journ. Boston Soc. Nat. Hist. Vol. VII, p.236.

(8) Worthen. A. H.—Bull. Illinois Ste. Mus. Nat. Hist. No. 2. p. 24. Geol. Surv. Ill. Vol. VIII, p. 104, pl. XI, fig. 3 a-c.

LAWS OF FORMATION OF NEW MEXICO MOUNTAIN RANGES.

By C. L. Herrick, Socorro, New Mexico.

PLATES XVI—XVII.

The writer has been engaged at intervals during the past ten years in collecting materials for a study of New Mexico mountain structure and, during part of this time, was engaged in practical mining operations in the Magdalena mountains. He hopes, therefore, that he may be permitted to point out what appear to be inaccuracies of a somewhat misleading nature in the paper printed in the American Geologist for January, 1904, under the caption, "Notes on Block Mountains in New Mexico."

In the general question at issue between Dr. Johnson and the writer of the article named the writer has no interest at the present time, and he certainly holds no brief for "block mountains," a term which needs to be quite loosely defined to be applicable at all to New Mexico mountains: In the discussion of this type of mountain structure much will depend on the definition of what are called "distributive faults."

When, however, the conditions in the Magdalenas are said to be "identically the same as in the Sandias, except that the fault scarp faces east instead of west, and there is no reason to suppose that there is more than a single great drop" we must demur. Still more impossible is it to include in one category the above mentioned with the Sierra Ladrones, the Manzano range, Sierra Oscura, San Andre(a)s, Franklin range, Sierra

Los Caballos, Fra Cristobal, and the San Mateo mountains," as is done in the paper referred to.

To take the most striking incongruity, the San Mateo range, as is well known, does not contain any stratified rock at all, in the range proper. It is a purely igneous uplift, with numerous flows of rhyolyte, rhyolyte breccia, tuffs, and, very likely, a core of andesyte or other basic eruptive. The writer has traversed the range on foot and on horseback in all directions and has never seen any stratified rock (except tuffs) in the range.There exist almost as great discrepancies in the remainder of the list given. In fact, the local differences are so great and the complications so unexpected, that it is entirely unsafe to generalize as to the several ranges or groups without some familiarity with them at close quarters.

The Sierra Ladrones, for example, differs from the others mentioned in that its entire body is of granite and the granitic peaks form irregular pinnacles and projections completely free from stratified rock, which latter (Carboniferous limestones on the west slope) lap upon the base for a short distance in a broad, even curve, with none of the abrupt block faulting so characteristic of the Magdalenas. It certainly cannot be brought into the category of "block mountains." This range is, throughout most of its mass, more simple than most New Mexico mountains in that it lacks to a large extent the true later intrusives.

In the classification tentatively employed by the writer in his private work so far, the descriptive terms are compounded of two elements, the first being descriptive of the materials (I. plutonic, II, neptunic, III, metamorphic) the second descriptive of the origin (I, erosive, II, eruptive, III, warping, IV, plastic-readjustive—plastic for brevity), and any range may be simple, compound or complex, or may be compound and complex.

In this classification, using the complete descriptive phraseology, the Magdalenas would be compound, complex, plutonic-metamorphic-neptunic, eruptive-plastic-erosive (and probably warping ought to be added). Warping commonly *is* involved with the plastic condition. The San Mateos, on the other hand, would be simple, plutonic, eruptive-erosive. The Ladrones are simple, neptunic-metamorphic, plastic-erosive (the main body of the mountain is here under consideration).

To return to the Magdalenas, the writer pointed out the main facts in this complex range in a brief paper published in the AMERICAN GEOLOGIST for April, 1897. To what was said in that brief description it is not necessary at this time to add descriptive details, particularly as a full account, with sections, is in course of preparation. The writer has gone over the western slope of the northern part of the Magdalena with a transit and has visited almost literally every foot of it. He has also made detailed reports on nearly all of the important mines in the various camps, often with transit and level work on the interiors, so that he is in a position to refer to actual data in rejecting the conclusions offered by Dr. Johnson's critic in some respects. It is true that the faulting system is not a pure illustration of "block faulting," as the writer pointed out in his earlier paper in 1897. The faults are not all of the same type or of the same age. They should probably not be called, in a very strict sense, "distributive" faults, but the quotation from Dr. Johnson's paper, on p. 21 of the article referred to, seems to the writer fully justified by the facts. The critic's statement is that "some of the principal fault planes bounding some of the so-called blocks are not fault planes at all. The phenomenon is produced by differential weathering of thick alternating beds of hard limestone and soft shale. The back slope slants about thirty degrees. Moreover, after going through the mines lower down on the mountains, where many minor faults are to be noted in the tunnels, the faults were found to be all too insignificant to even show their presence on the weathered mountain slope."

This passage is liable to produce a very misleading impression. In the first place, the faults, in some cases, have a drop of several hundred feet. It is true that in the limited sphere of any one mine the work has necessarily been included within one of the major blocks. In one case, the entire block has been removed, leaving bare granite and quartzyte on a large part of the mountain side in what is known as the Jaunita gulch. The exposed sides of the remaining blocks show from a distance of several miles with the "diagrammatic clearness" of which Mr. Johnson writes. To the south, where the major faults become nearer to one another, by reason of the radial nature of their distribution figured in my earlier article, the close-grained red sandstone of the Permian is brought by faulting to the level of the Carboniferous strata of the lowest local horizon. No mine tunnel has penetrated the ore-bearing strata of this area and it is fair to presume that the dislocation is several hundred feet. It is, in fact, hard to tell what should be called the "great fault" referred to by Mr. Johnson's critic, for it would be fair to presume that by this is intended the fault following the crest of the range. But the crest is uneven and many different faults occupy that position. The entire lime belt crosses the range to the south, being thrown east by the uplift of the andesyte crater at the head of Hop cañon. It may be followed for miles into the heart of Water cañon, where it still preserves the distinctive type of mineralization though impregnated with gold in the neighborhood of the andesyte, so that lead ores that in other parts of the camp carry only a little silver, here occasionally bear one or two ounces of gold and considerable silver.

In the centre of the lime belt, where the structure may be said to be quite typical, there exist lime beds to the east of the axial fault which are displaced over three hundred feet, adhering to the eastern slope and separated from the main body on the west by an interval of granite, indicating a still greater dislocation.

To the north of the range, where the erosion has been more active, there are places where there remain only a few hundred feet of lime at a high angle and representing only about one hundred feet in thickness of the original lower (ore-bearing) strata, imbedded in granite and surrounded on all sides by it.

The phenomena of "differential weathering" referred to are, indeed very beautiful and are worthy of special interest because they illustrate a fact, often overlooked, which may be called a "law," namely, that, where soft strata are faulted and left on a slope, the escarpment tends to move from the fault plane and, in the case of strike faults, particularly, the movement will be considerable and down-hill.

The explanation of this is not far to seek. An escarpment facing the slope (i.e. east in the Magdalenas) is met at its base by a slope in the opposite sense. The waters flowing down the back slope encounter, in the trough, the edges of the strata, while the waters (less abundant as a rule) from the escarpment encounter the surface of the strata. The edges erode rapidly and the surfaces slowly, especially when a bed of limestone is reached. In no very long time the original escarpment has been moved from its original site and one might be tempted to ignore the causal connection between the faults and the escarpment. Such a case occurs to the writer above the Graphic mines where soft shaly limestone is left in an abrupt escarpment from the base of which eastward to the base of the back slope proper there is a long level interval. This is one of those very prominent structural features that would have seemed to Mr. Johnson to illustrate his point with "diagrammatic clearness." In this case, the fault is there and a profound one; there is, in fact, a reversed-dip area, i.e. a thin portion dipping east instead of west. A careful examination would convince any geologist that the escarpment is due to the faulting. The fallacy would be in supposing that the amount of the projecting escarpment would be the measure of the drop of the fault. The result would be the same if the drop were very small provided the opportunity of differential weathering were afforded.*

But, as stated above, the Magdalenas are not a good illustration of block mountains. Mr. Johnson's critic ascribes the origin of the faults to the "attempt of the brittle limestones forming the back slope to adjust itself to a complexly warped surface produced by the major faulting." The case is not by any means so simple as this might be understood to imply. The limestones, quartzytes and shales of the Carboniferous and the sandy layers of the red-beds have suffered from a variety of disturbances. It is not yet possible to say with certainty at what geological period the major system of faulting occurred. We do know, however, that the great andesyte uplift, which attended the origin and subsequent history of the primary volcanoes of the range, profoundly affected the stratified series. This is attested by the fact that the brecciated andesitic lavas near the sedimentaries are filled with fragments of the sediments and of the granites underlying them, and that great masses of the Permian and other sedimentaries are caught up in and comminuted by these andesitic flows. These phenom-

* The writer can recall no prominent structural feature in the area covered by stratified rocks in the Magdalenas which cannot be traced more or less directly to the faulting.

ena are very evident near the South Camp district. We may be justified in assuming that the range at the northern extremity, having been undermined to the west by the vast fluid intrusion of basic lava (extending westward many miles) dropped to the west, forming, in major outlines, the range as we now see it. The andesitic outlyers were radial with reference to the present axis of the range, one being to the east, as well as one to the west. In the course of these disturbances there were, very naturally, some intrusions of basic lava into the up-tilted area. Erosion may have continued this work till the range had assumed something of its present state, when the second disturbance occurred. This was acid. It may have been anacharitic along a fissure extending somewhat parallel to the edge of the andesyte. In any event, it not only spread enormous sheets of rhyolyte, acid glasses, obsidian, obsidian tuff in rhyolitic base, etc., covering the country at large for many miles and left by erosion in some of the nearer buttes, like Magdalena mountain and Elephant butte, but it produced a series of hills lying along the present western margin of the stratified rocks from Hop cañon north-westward. This line of rhyolyte hills is seen west of the town of Kelly and at North Camp, north of which it forms high conical peaks still nearer the range. This rhyolitic uplift evidently played its part in the "warping" referred to, and from it dikes intrude themselves into the strata. The edge of the overlying strata are greatly disturbed and the faults do not obey the same law as nearer the axis; they even, in some cases, come to be dipping to the south, or nearly at right angles to the range. These blocks cannot be brought within the embrace of any system of distributive faults. Nor is it a matter of warping due to direct uplift, alone, for the subjacent granite series at one or both of the eruptive periods mentioned, suffered great metamorphism and was reduced to a paramorphic condition terminating in what appears to be a dioryte, but in all cases charged with chlorite, epidote, and calcite. Dikes of this secondary intrusive are very abundant and fill an irregular series of faults not belonging to the original system. In such dikes there are frequently fragments of undigested quartz with corrosion phenomena.

In my earlier paper the effect of the rhyolyte intrusion was not sufficiently emphasized. Without anticipating the final paper, probably enough has been said to permit a comparison with the other types of mountains named.

The Caballos have been referred to as co-ordinate with the Sandias and Magdalenas. Both the San Andres and the Caballos were described incidentally in the AMERICAN GEOLOGIST for November, 1898, in connection with a few remarks on the occurrence of copper and lead in New Mexico. The figure on page 289 will serve to show that the Caballos are of a much simpler type. In the section there given, while there is evidence of very profound metamorphism in the granites and lower stratified layers, still one might say that this is an illustration of a tolerably pure block mountain. In our classification it would be neptunic-metamorphic, warping (or plastic) erosive. Indeed the erosive element does not greatly obscure what must have been the original facies. Everything, from the Subcarboniferous to the Cretaceous, is involved and the series of "distributive" faults extends several miles further east. This might be taken to represent the type given by Johnson in his diagram No. 3, even to the dropped block "a," though the case is not quite so simple as is represented. In these cases it is hardly proper to speak of the uplift; in most cases it is demonstrably a depression on the down side which is responsible for the faulting.

Passing to the Ladrones, which are also included by the critic in the category of block mountains, we have an entirely different type. Here is undoubtedly a metamorphic uplift. The vast isolated granite peaks of the central mass are like none of their neighbors. The Carboniferous limestone on the flanks does not break into the block faults described in the other cases, at least the faulting is insignificant and the strata arch gently for miles to a horizontal position. The limestone is the same as that of the Limitars and Socorro mountain and contains *Productus nebrascensis, Athyris argentea, Spirifer camerata* and the familiar association, but the stratigraphical relations are very different. The range is metamorphic-neptunic, plastic-erosive.

One further distinction may be in place here. The difference in behavior of stratified participants in a complex mountain can be predicted, in general, from the nature of the association. If the intrusive be a true igneous intrusive, the stratified fragments will dip toward the centre of the mountain (introrse), if, on the contrary, the core be of metamorphic material the strata will dip from the centre or axis (extrorse). This law seems of quite general application. In the Ladrones, Magdalenas, Sandias, Manzanas, San Andres, Oscuros, Caballos, Fra Cristobal, and numerous others, the dip is away from the granitic core. In the Limitar, Socorro, Black mountains and many more, where the core is igneous, the strata dip toward the theatre of activity and the evidences of interaction are very interesting. In volume I of the Bulletins of the University of New Mexico the writer has given brief description of both the Limitar and Socorro mountains and the relation of the sedimentaries to the later intrusives is sufficiently discussed for the present purpose. In that paper attention is called to the curious fragmental andesyte tuff above the limestone from which it derives its calcite magma. Toward the north end of the ranges, at a point not visited at the time the paper was written, there is an area of explosive volcanic activity of the rhyolyte period which affords a very interesting illustration of the method of formation of talus conglomerates. Two fork-like rhyolyte ridges, uniting with the main peak of the Limitar at their base or point of union, embrace an area of over a mile square filled with the evidences of explosive flows. The material is all rhyolitic, but it has been poured into water and suffered some rounding afterwards, and then has been compacted into irregular conglomerate, breccia (near the rhyolyte itself) and tuffas of all sizes, the materials growing smaller as one leaves the focus. The dip is high and away from the focus, forming an arch to the east, northeast, and north. Surrounding this area is what has been regarded as late Tertiary in well-stratified beds composed of similar materials, but with some admixture of other elements from the range. The dip is confused and the materials at a distance from the mountain grow finer and red in color. They seem to belong to the same series as the (Pliocene) Tertiary sandstones so prominent on the east side of the Rio Grande at this place. These beds disappear under what we have called the clinoplains of the Pleistocene age.

In the papers on the Socorro and Limitar mountains we considered that the Rio Grande occupies a great monocline on the east side of the river. The data in substantiation of this claim have never beeen published and I venture to offer the evidence from a section directly eastward from the Socorro mountain, beginning at the river. In the ascent of one of the large arroyos opening upon the flood plain opposite the School of Mines one may see the relations very clearly and the section given supposes the bed of the arroyo exposed in one section running east and west.

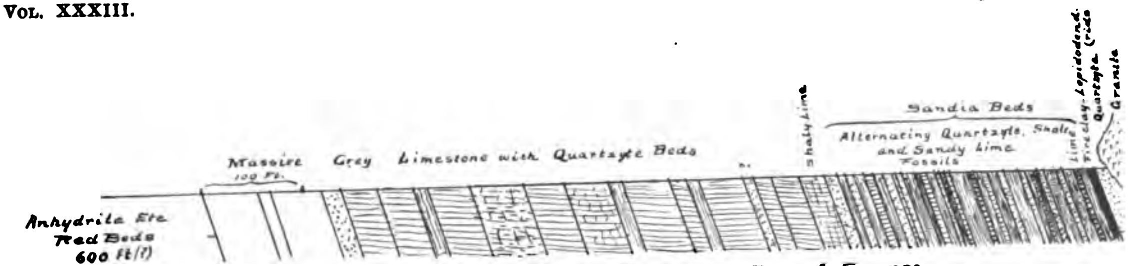
For the first three miles and more the red and grey Tertiary beds rise on either side to a hight of some 50 feet. Their materials are loam and gravel at first, with sand-bar and local gravel beds at times. For the most part, the stratification is very true and persistent, contrasting, in this respect, with the Pleistocene beds near the river.

The dip is to the west and is slightly greater than the inclination of the arroyo. It may be as much as 25 to 50 feet per mile. Toward the east, as one approaches the foot-hills, the materials become coarser and consist of granitic pebbles, fragments of Carboniferous and red-bed strata. Abruptly the strata of sand and coarse pebbles abutt upon the irregular surface of the granite which is evidently smoothed by water-erosion, and the parts of the strata immediately adjacent to the granite are filled with conglomeritic masses of the granite to the exclusion of the other ingredients.

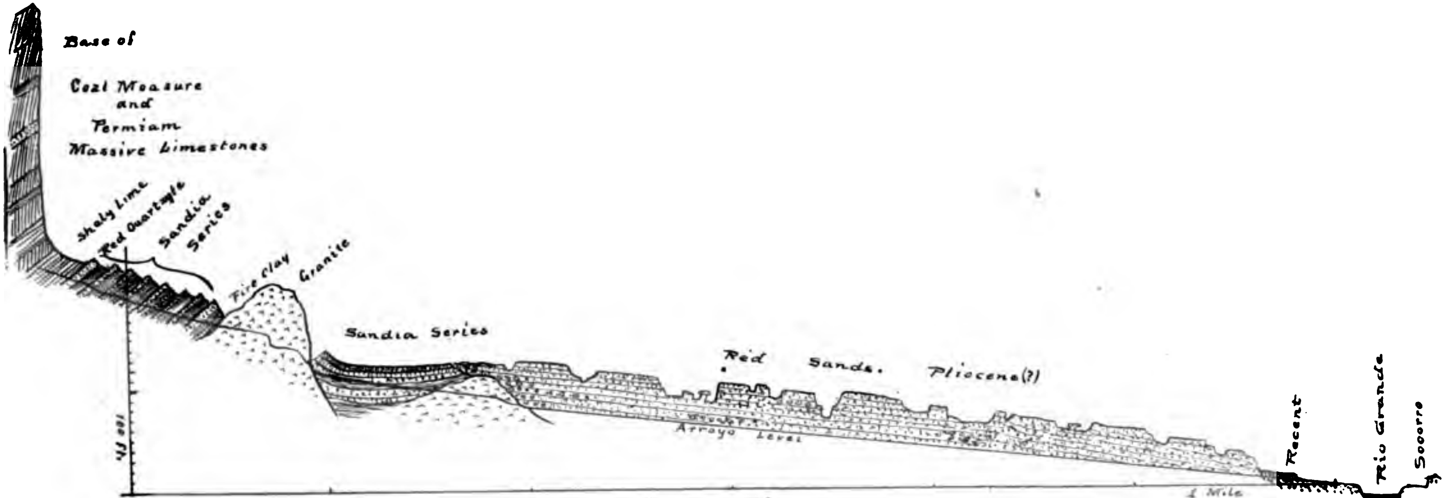
East of the first exposure of granite is a basin-like interval in which lies a portion of the lower beds of the same series exposed in the Socorro and Limitar mountains. These lower beds dip to the east and repose on the granite. They consist of prevailing quartzytes and sandy shales with beds of limy shales and sandy limestones of a peculiar character. There can be little doubt that this series is the same as that found at the lowest horizons in Socorro mountain, below the large quartzyte beds. The exposure is imperfect and very incomplete at that place, while here it is well shown. The eastern wall of the basin referred to is formed by an abrupt exposure of granite rising to over one-hundred feet above the arroyo. The strata lap at a high angle against this granite boss, while on the eastern side they are repeated and the whole magnificent series of Coal-Measure and Permo-Carboniferous rocks is within easy reach and in uninterrupted sequence. This series will be described in detail elsewhere, but it will be of interest to show that the base of this exposure is certainly of Coal Measure age. Resting on the granite is a quartzyte, as usual, but above it and locally well-developed, is a bed of blue shale and fire-clay that has been extensively mined by the Socorro Fire Clay Co. From these beds were collected the lepidodendrids figured in the Bulletins of the University of New Mexico, Vol. II, Plate VII, figs. 1 to 4. These were recognized as Coal Measure species, though they may prove new, but nothing definite was known as to their position with reference to the known horizons. But in this locality there are superposed upon these shales in unbroken succession over 200 feet of alternating sandy shales, sandy limestones, and quartzytes or sandstones, in which is preserved an abundant fauna of undoubted Coal Measure habitus. (Plate XVI.)

This sandy series corresponds in position to what we have called in Bernalillo county the "Sandia series" of the Carboniferous and it is immediately followed in both places, as well as at Socorro mountain, by a series of shaly limestones affording the most complete Coal Measure fauna yet observed in New Mexico. The transition into the Permo-carboniferous is affected very gradually through several hundred feet of massive grey limestones with few quartzyte beds.

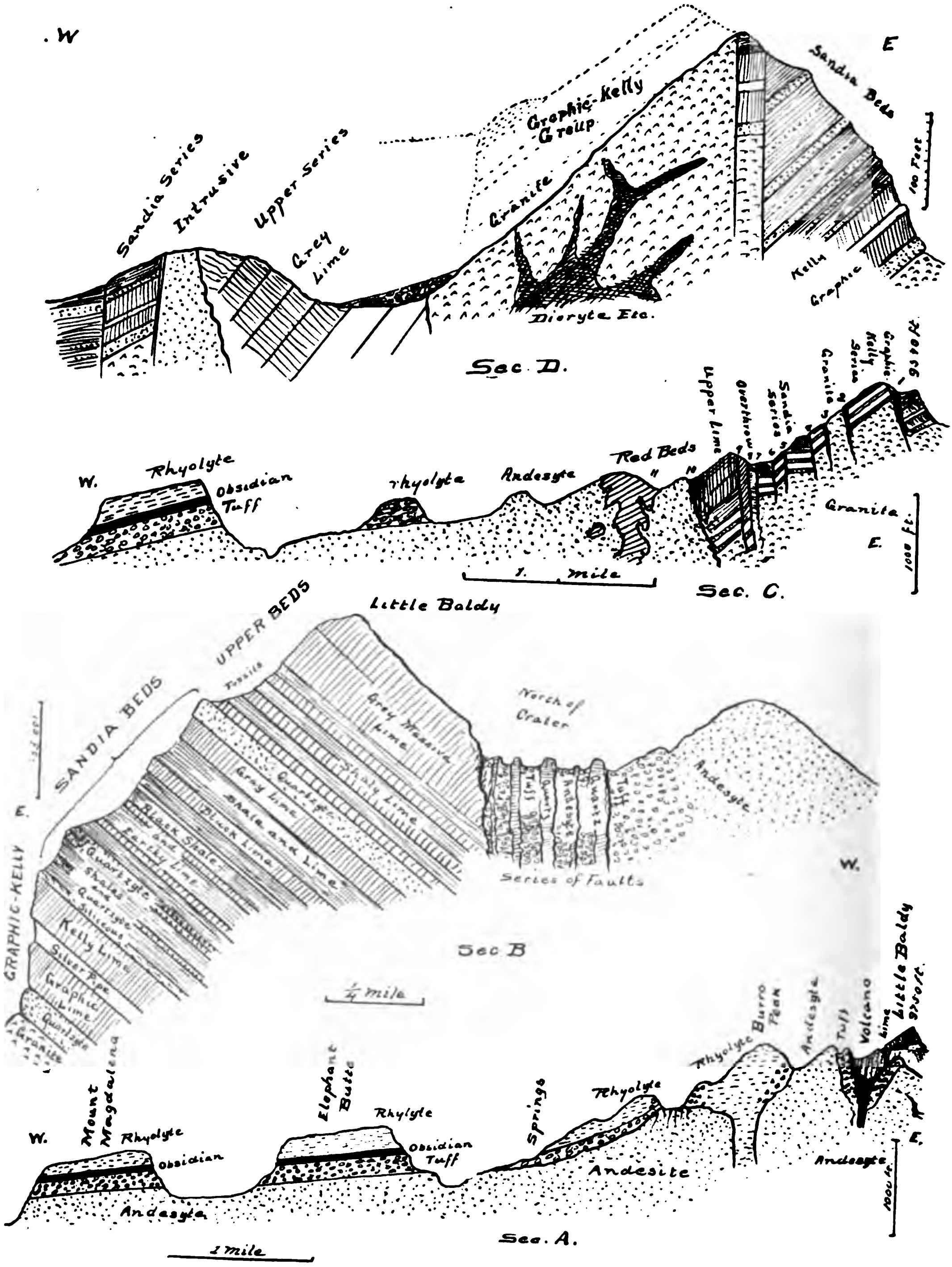
The above observations acquire greater significance when we remember that further southeast, in the Sacramento mountains, the writer has found a well defined Burlington series beneath the Sandia strata and that in the extreme southwestern part of the territory the Burlington and strata evidently older (probably Devonian)are known to occur. There is a very general belief that the lower 100 feet in the Magdalena range may be older than the Coal Measures, though the bulk of the rocks are late Carboniferous and Permo-Carboniferous. The writer has seen no paleontological evidence for the Sub-Carboniferous in the range and by reason of the analogy with the Socorro mountains and other adjacent regions where metamorphism is less destructive to fossils, has regarded the whole limestone series as probably as late as the Coal Measures. Sub-Carboniferous crinoids, however, in two cases, are said to have been found in the ore-bearing horizons and more light may be eventually expected on this point.



Base of Carboniferous East of Socorro.



Approximate Section East of Socorro.


W
E
Sandia Series
Intrusive
Upper Series
Grey Lime
Graphic-Kelly Group
Granite
Dioryte Etc.
Sandia Beds
100 Feet
Kelly
Graphic
Sec. D.
W.
Rhyolyte
Obsidian Tuff
rhyolyte
Andesyte
Red Beds
Upper Lime
Sandia Series
Granite
Granite
1000 ft.
E.
1 mile
Sec. C.
Little Baldy
UPPER BEDS
SANDIA BEDS
GRAPHIC-KELLY
E.
Grey Massive Lime
Shaly Lime
Grey Lime
Black Shales
North of Crater
Tuff
Quartz
Andesyte
Series of Faults
W.
Kelly Lime
Graphic Lime
Granite
Sec B
¼ mile
W.
Mount Magdalena
Rhyolyte
Obsidian
Andesyte
Elephant Butte
Rhylyte
Obsidian Tuff
Springs
Rhyolyte
Andesite
Burro Peak
Tuff
Volcano
Lime
Little Baldy
E.
Andesyte
Sec. A.
1 mile

DESCRIPTION OF PLATE XVII.

These cross sections are, of course approximate only and the vertical scale is greatly exaggerated. They serve to show, in a general way, the distribution, and also to suggest the cause of the faults referred to in the paper.

Section A. is a section from north-west to south-east through the crater immediately north of Little Baldy. The line of section is somewhat curved to cut the two isolated peaks. Little Baldy peak is brought into the section to indicate the relation of the stratified rocks in the immediate vicinity of the area of disturbance.

Section B is on a larger scale and is a diagrammatic section of Little Baldy looking south (the other sections are seen from the south). The numerous fault lines at the foot of Little Baldy on the west run into the crater to the south in a few yards and diverge towards the north to become widely separated and profound faults. The section on the east slope is a very good one and shows in detail the presence of the three main divisions of sedimentaries. What I have called the Graphic-Kelly formation consists of crystalline and light-colored lime, separated by a close-grained, dense lime, resembling lithographic stone, known locally as the "Silver-pipe" lime. It is the bearer or supporting zone for the great stopes of ore. This property it has by virtue of affording an entrance to water that dissolves the overlying crystalline limestone to variable extents. The ore accumulation is usually along faults at the intersection of the silver pipe lime. The Sandia series is well-developed and consists, as usual, of shales, quartzytes and sandy lime beds. There are a few fossils of the usual types. Above this series is the very fossiliferous base of the upper series with the large type of *Athyris argentea,* as contrasted with the small form in the Sandia beds. The massive upper lime series is only partly represented.

Section C. is nearly east and west and includes Elephant butte on the west and crosses the main range. The region of faults is proportionally somewhat narrower than here shown, and some of the minor faults are omitted. The equivalent of the two benches, at 7 and 11 respectively, can be traced for miles along the slope of the range, appearing as plateau-like flats on each of the cross-ridges and giving unmistakable evidence of the continuity of the great faults when seen from a distance of five miles or more. In this section the red-beds, or "Permian" sandstones, are present, as they are for a distance of over a mile at the appropriate position. They may be well seen near the town of Kelly and, of course, represent a dislocation of at least a thousand feet as compared with the Coal Measure beds into juxtaposition with which they have been so forcibly brought.

Copper-silver deposits have been mined near the little rhyolyte eminence indicated and are ascribed in some of my papers to digested Permian strata. This is, of course, a mere guess.

Section D. is farther north, not far from the town of Kelly, but does not embrace the whole section, which has grown quite wide at this point. The section passed down a gulch in which the limestone has been removed and the relations of the adjacent regions is indicated by dotted lines. The profound faulting is very evident from a distance at this point. The red beds are still to the west. The section is abbreviated and condensed to the west in order to give room to display the strata on the east slope. The elevation is about 9500 at the apex of this section.

ANCIENT LAKE BEACHES ON THE ISLANDS IN GEORGIAN BAY.

By FRANK M. COMSTOCK, Case School of Applied Science, Cleveland, Ohio.

PLATES XVIII—XIX.

One day several years ago while following the trail between "the chimneys" and the Indian village on Beausoleil island, one of the larger islands in the southeastern part of the Georgian bay, the traces of several old shore lines were seen so plainly recorded in the sandy soil of the island, that it seemed to the writer that the locating of some of the more prominent of the ancient lake beaches upon the islands of the bay would be an interesting problem. In the literature of the subject available to the writer no record of these beaches among these islands was found, though Taylor* and Spencer† had both recorded beaches at several points on the main land at this end of the bay. A few days therefore in the summers of 1900, 1901 and 1903 were made available for the purpose and three of the islands in the southeastern part of the bay were examined rather carefully. The results of these examinations are given herewith.

The altitudes in most cases were taken with an aneroid barometer, though a hand level was also used as indicated below, and the hights reduced to the mean level of the bay (582 feet). At the dates when the measurements were made the level of lake Huron was about two feet below the normal (580 feet).

The islands on the "north shore" of the Georgian bay, numbering over thirty thousand, are for the most part rocky and sparsely timbered. They vary in size from a small rock to an

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* "The Limit of Post-Glacial Submergence in the Highlands east of Georgian Bay." AMERICAN GEOLOGIST, vol. xiv, p. 273.
"The Second Lake Algonquin." AMERICAN GEOLOGIST, vol. xv, p. 100.
† "Deformation of the Algonquin Beach and Birth of Lake Huron." *American Journal of Science*, 3rd, vol. xli, p. 12.

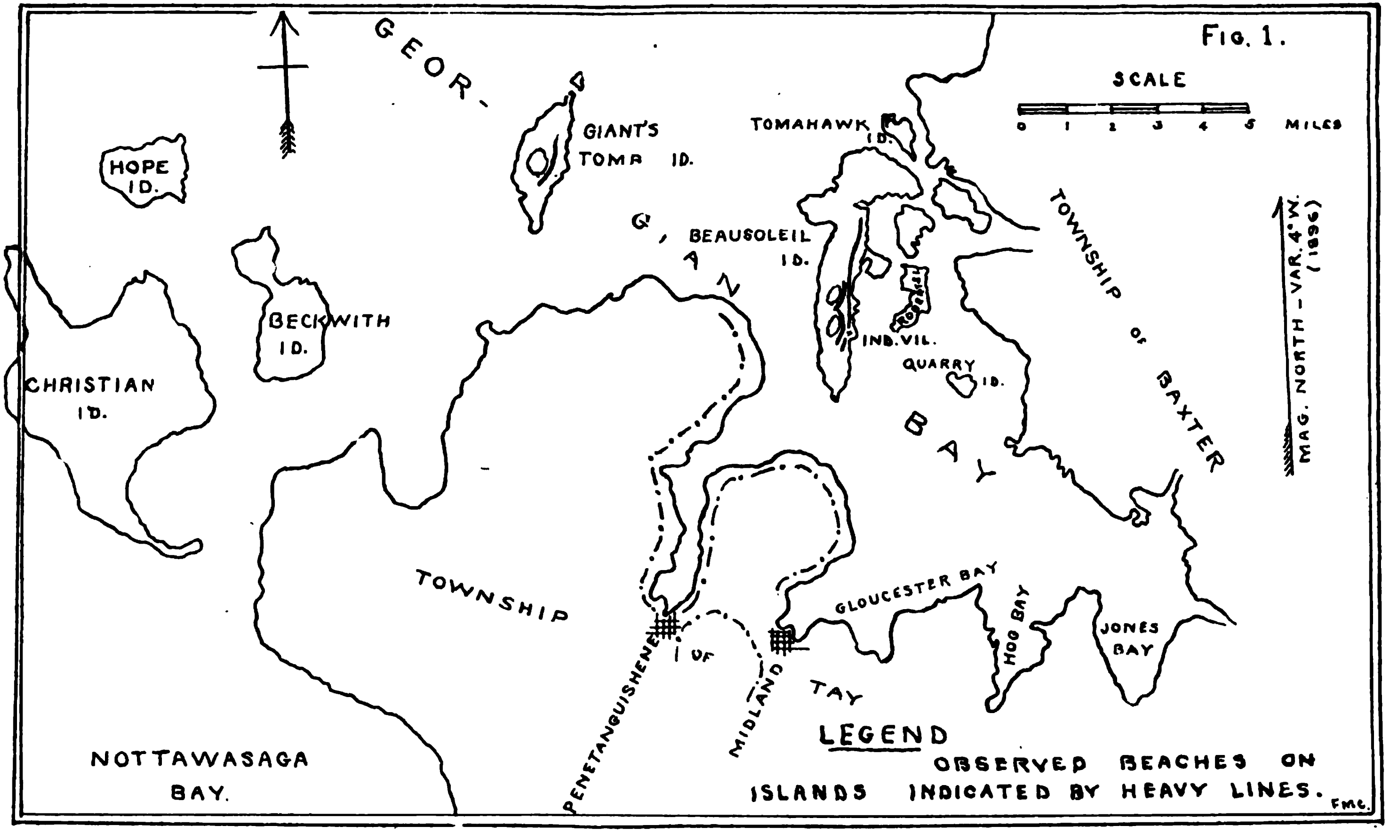


FIG. 1.
SCALE
0 1 2 3 4 5 MILES
GEOR-
G, A N
BAY
HOPE ID.
BECKWITH ID.
CHRISTIAN ID.
GIANT'S TOMB ID.
TOMAHAWK ID.
BEAUSOLEIL ID.
IND. VIL.
QUARRY ID.
TOWNSHIP OF BAXTER
MAG. NORTH - VAR. 4° W. (1896)
TOWNSHIP
PENETANGUISHENE
OF
MIDLAND
TAY
GLOUCESTER BAY
HOG BAY
JONES BAY
NOTTAWASAGA BAY.
LEGEND
OBSERVED BEACHES ON ISLANDS INDICATED BY HEAVY LINES.
FMC.

extent of several thousand acres and rarely rise to a hight of over fifty or sixty feet above the water of the bay. The three islands so far examined, viz:—Tomahawk, Beausoleil (sometimes called Prince William Henry) and Giant's Tomb, are shown on the accompanying sketch (Fig. 1) in their relation to each other and to the adjacent mainland.

On this sketch the locations on the islands of the beaches described in this article are indicated by the full heavy lines. The positions of the beaches on the mainland, plainly visible from the steamers on the bay, and described by Spencer and Taylor, are roughly indicated by dash and dot lines.

The sketch was compiled from the Canadian Hydrographic Office chart No. 327 and the maps of the Department of Indian Affairs for Canada.

Tomahawk island and the northern portion of Beausoleil are of the characteristic rocky formation and rise to a hight of about sixty feet. The scanty soil which is found in a few places is composed of the disintegrated Laurentian rock and vegetable remains. In marked contrast to these are Giant's Tomb and the southern portion of Beausoleil. These are sandy with sloping shores and are both marked by high hills of unstratified sand, gravel and boulders and are evidently of glacial origin.

Beausoleil island, which was the first island examined, was visited several times. This island is about five miles long, the northern rocky portion being irregularly two miles each way, while the southern sandy part is about three miles north and south by less than a mile in width. This portion appears to be composed entirely of material derived from the two glacial hills which rise from near its middle, and was probably at one time a separate island, joined later to the northern part by material carried north by wave action and by the falling of the water level.

The two hills on this island are of an irregular oval shape probably a little over a quarter of a mile long and with the longer axis bearing north twenty-five degrees east. The northern hill was found to be 105 feet (bar.) above the water at the highest point visited and the southern 84 feet (level and bar.). They are both composed of unstratified sand, cobbles and small boulders and have flat tops.

Between the two hills the land sinks to a level of fifty-five feet above the bay or about the hight of the Nipissing beach of Spencer.

On the northern part of the island no traces of old lake beaches were noticed, but on the sandy southern portion, especially on the southern and eastern sides where the wave action was less violent, they were found in great abundance and variety. On the eastern sides the records of these old lake levels vary from low sandy ridges of three or four feet high to a wave-cut cliff of thirty-five feet marked at the bottom by excellent examples of boulder pavement. As many as seven or eight different water levels have left their records on this side of the island. One of the most prominent of these levels is marked by a strong beach of fine sand, in some places ten to fifteen rods wide, which was followed for over two miles. This beach has a hight of twenty-two feet (level and bar.) above the mean level of the bay near the southern hill where the material is most abundant, and falls gradually to a hight of sixteen feet or even less two miles to the north at its greatest distance from the hills and the source of its material.

On this beach are located some of the cabins of the Indian village southeast of the southern hill and also the ruins called "the chimneys" two miles to the north. These "chimneys" are the ruins of some dozen or so cabins, of which little is now left except the remains of the brick and stone fireplaces and chimneys, which tradition says mark the last settlement of the Huron Indians and the Jesuit priests before the extermination of that tribe about the middle of the seventeenth century. At this point the ridge is about fifteen rods wide, and its composition of fine sand is excellently shown in the numerous excavations made by seekers after the traditional buried treasure of the Jesuits.

Between this beach and the water is another well defined beach at about nine or ten feet above the water of the bay.

The most prominent of all the shore lines on this island is probably the Nipissing beach of Spencer. This is best seen as a fine terrace cut into the southern hill back of the Indian village, plainly visible from the steamers from Midland to Penetanguishene (Fig. 5).

This terrace was followed for some two miles and is well defined on the southern and eastern sides of the island where the hight of the surface is sufficient to show it. Back of the village its hight above the bay is sixty-six feet(level and bar.), but in several other places its hight was found by barometer to vary from fifty-three to fifty-seven feet. The greater elevation near the village may possibly be due, in part, to the ac-

FIG. 5.—Wave-cut terrace against hill on Beausoleil island. The arrow indicates the terrace.

cumulation of material upon it from the slope above, as the surface is here unwooded and quite bare while at the other points where measured the surface was quite well protected by timber.

At one point against the eastern side of the northern hill this beach has a hight of fifty-seven feet from which a uniform slope covered with cobbles and small boulders rises to ninty-one feet where it meets the nearly vertical face of the hill rising to 105 feet, the general level of the top. On this line the western side of the island descends abruptly from 105 feet to 91 feet again—the same hight as the base of the cliff on the opposite side—and is marked at this hight by a boulder pavement. From here the slope is uniform and gradual for nearly half a mile to the water's edge, with no sign of old water levels. This long slope is strewn with large and small boulders in great profusion.

A profile across the island from east to west through the northern hill is shown in Fig. 4. The line of this profile started at a point on the eastern shore where the old beaches below forty feet are lost in a strong wave-cut cliff thirty-five feet high rising from a few feet above present water level.

Giant's Tomb island which is situated about six miles north of west from Beausoleil island is about four miles long by one mile wide. It is named from the appearance of a large flat-topped hill near its center which resembles an enormous grave when seen from a distance of several miles. This hill, which rises to a hight of 172 feet at the highest point measured and has a maximum diameter of probably three-fourths of a mile, is one of the most prominent features of this portion of the bay, and is a familiar landmark visible for miles from any direction. It is evidently of glacial origin and its sand, gravel and boulders have no doubt furnished the material from which the whole island and its surrounding shoal have been composed. No country rock was found in any part of the island.

The shoal surrounding the island varies in width from one hundred to eight hundred feet. Upon this shoal the water is less than six feet in depth, but at the edge of the shoal the depth increases abruptly to many times that amount. The shoal is in fact a wave-formed terrace or shelf covered at various points with sand, gravel and magnificent examples of boulder pavement. In other places, more exposed to violent wave action, the covering is of large boulders up to six and eight feet in diameter. A fall of ten feet in the water level of the bay would probably increase the area of the island by twenty-five per cent and uncover a fine example of shore line.

Several trips across the island showed that the sandy surface of the eastern side rises gradually from the water to the foot of an abrupt rise of from twenty to fifty feet in different places, carrying one to the top of the hill. This sandy slope is covered with the records of old water levels. Ridges, terraces,

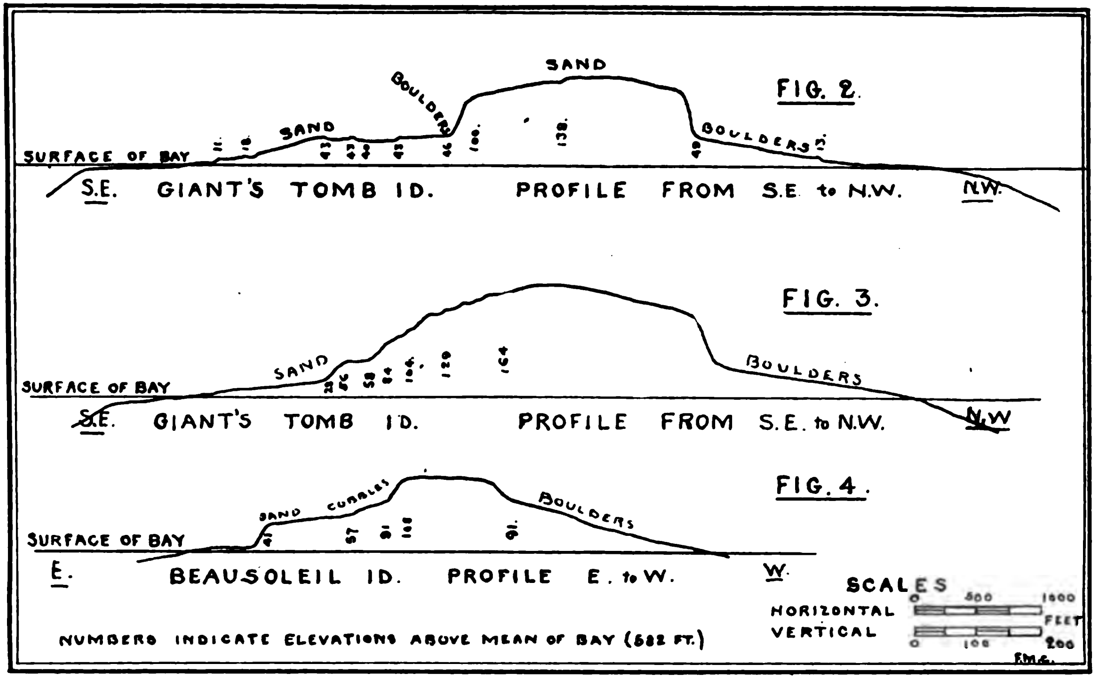


FIG. 2.
SAND
BOULDERS
SAND
BOULDERS?
SURFACE OF BAY
S.E. GIANT'S TOMB ID. PROFILE FROM S.E. to N.W. N.W.
FIG. 3.
SAND
BOULDERS
SURFACE OF BAY
S.E. GIANT'S TOMB ID. PROFILE FROM S.E. to N.W. N.W.
FIG. 4.
SAND
COBBLES
BOULDERS
SURFACE OF BAY
E. BEAUSOLEIL ID. PROFILE E. to W. W.
SCALES
HORIZONTAL
VERTICAL
FEET
NUMBERS INDICATE ELEVATIONS ABOVE MEAN OF BAY (582 FT.)
F.M.C.

spits, etc., are well developed and follow each other closely On all profiles, but one, which were followed on the island, the Nipissing beach was clearly marked at a hight of fifty-eight to sixty feet above the bay which would be its proper altitude accepting its hight at Midland as fifty feet and using Spencer's ratio of increase in hight towards the north. Other prominent beaches were noticed at 11, 18, 43, 84, 129, and 143 feet above the bay, besides several less prominent ones. A series of four small ridges was found lying between 129 and 143 feet.

On the exposed western side of the island the surface of the ground drops precipitously from the level of the hill top to a boulder pavement at from fifty to seventy feet below the top at different points. From this pavement the slope falls away uniformly and gradually to the water's edge nearly half a mile away. The surface of this gradual slope is so thickly strewn with boulders as to make the travelling quite difficult. On the line of the profile shown in Fig. 2 a slight ridge at thirteen feet above the bay seems to mark an old shore line and was the only break noticed in the uniform slope from the hill to the water on the western side of the island.

Figs. 2 and 3 show two profiles of Giant's Tomb island. The vertical hights are exaggerated to five times the horizontal distances.

Fig. 2 is along a line from southeast to northwest across the widest portion of the island, and near the northern end of the hill, whose highest point on this line is 138 feet, marked by a slight ridge of sand indicating an old water level.

Fig. 3 is on a line nearly parallel to that of Fig. 2, but at the south end of the hill whose slope the line ascended somewhat at an angle instead of directly as in Fig. 2. On this line the successive beaches are shown very clearly, seven being noticed between the Nipissing level and the highest point of the line—172 feet above the bay.

The third island examined was Tomahawk island quite near the mainland and opposite the northern end of Beausoleil island. Tomahawk is a characteristic rocky island about three quarters of a mile long in its greatest length and rising to fifty or sixty feet above the bay.

The rocky formation of the island would largely prevent a short-lived water level from leaving very prominent records of its existence. Very careful search revealed one or two rocky shelves on the southwest side which might have been cut or modified by wave action, but there is not enough evidence to warrant such an assertion.

On the western side of the island where the exposure to wave action is more complete a fairly well developed pebble beach was traced for a few rods at a hight of thirty-two feet above the bay. This was the only definite trace of an old shore line that was discovered.

A number of other rocky islands and a few high points on the adjacent mainland were visited, but a hurried examination discovered no traces of old shore lines.

On a high point of the mainland about four miles northeast of the northern extremity of Giant's Tomb island and about forty or fifty feet above the bay are several pot-holes locally called the "Indian kettles." These pot holes are three or four feet in diameter and six to eight feet deep. They are cut in the Laurentian rock a few rods back from the mouth of one of the branches of the Go Home river.

The traces of the old water levels among these islands are evidently to be sought with the best success upon the high islands of glacial materials as is shown by the results of the examinations of Beausoleil and Giant's Tomb islands.

The descriptions of Hope, Beckwith and Christian islands in the "Georgian Bay Pilot" indicate that they are largely composed of glacial drift, and it is hoped that at a future time these, as well as other islands further north, may be examined, where it is hoped that further records of the old water levels will be found.

Mont Pele. The new spine from the basin of the Lac Des Palmistes, looking ab
S. 60° W. The apex is about 333 meters (1092 feet) above the river directly
is front. Photographed May 25, 1903. By E.O. Hovey, (*Am. Jour. Sci.*)

Mont Pele. The new spine from beside the head of the gorge of
Blanche, looking about N. 30° E. The apex is about 50

EDITORIAL COMMENT.

PELÉLITHS.

PLATES XX-XXII.

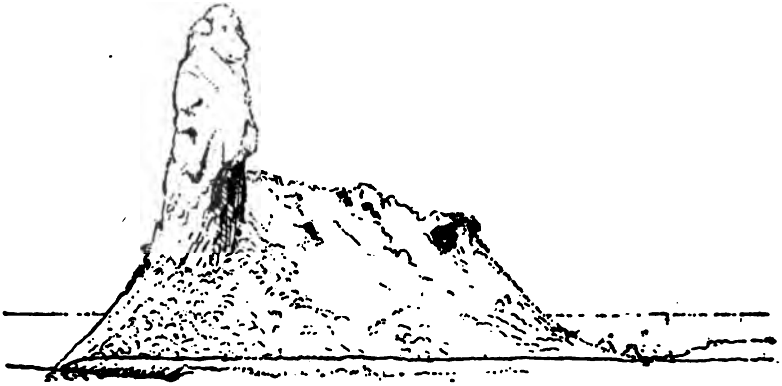
The very remarkable ascent of the rock cone in the crater of Mont Pelé has attracted world-wide attention. Several similar peaks have been described, and several others might be. In view of the frequency of this form of volcanic plug it is proposed to apply the term *pelélith* to such peaks, the type illustration being the peak of Mont Pelé on the island of Martinique.

Following the admirable description of the Pelé cone by Dr. E. O. Hovey* from whose account the figures of plate xx are extracted by permission of the editor of the *American Journal of Science,* Dr. J. C. Branner called attention to the similarity of the peak of Fernando de Noronha, illustrating it by figures which are reproduced below.† According to Dr. Branner Sir Richard Strachey, in *Nature,* Oct. 15, 1903, calls attention to a peak in India of which the Mont Pelé peak reminds him.

The writer in 1874 examined Bear butte in South Dakota, which stands on the plains about six miles east of the northern part of the Black hills. It consists of phonolyte, the same rock which forms the peak of Noronha. It is isolated from the hills, rising in the midst of the Fort Benton shales, of the Cretaceous, to a hight above the level plains of 1200 feet. It is a singular conical mass, steep on all sides and difficult to climb. It is surrounded, not much above the level of the plains, by a ring or horseshoe ridge of rock which consists apparently of some sedimentary strata more or less tilted away from the butte. The rock of the central mass has not a distinct columnar structure, but splits on weathering into slabs from half an inch to two inches in thickness and not usually exceeding ten inches in extreme dimension, constituting a shingle that forms a copious talus on all sides. The summit is in the form of a ridge elongated northwest and southeast.

* *American Journal of Science*, October, 1903.

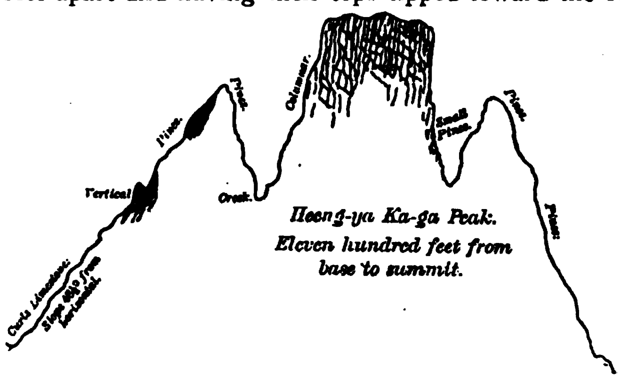
† *Am. Jour. Sci.*, December, 1903.



The peak of Fernando de Noronha seen from the plateau above the village. From a sketch by J. C. BRANNER in July, 1876.

The peak of Fernando de Noronha seen from the land to the south. From a photograph made by J. C. BRANNER in July, 1876.

On the opposite side of the Black hills and a little further south is Inyan kara (pronounced by the Indians Heeng-ya-kagá). This was also examined by the writer, who gave the appended illustration.* This rock also is phonolyte. Newton, however, states that it is trachitic, with crystals of sanidine sparsely disseminated. The central mass is almost entirely surrounded by a rim of rock similar to that of the central mass. The sedimentary beds of the Carboniferous strata lie at steep angles against the flanks of the rim, but do not rise more than 500 feet above the plain. "The shape of the summit which at a distance has the aspect of a small saucer lying on a larger one, both inverted, is caused by the central mass rising above the rim or ridge by which it is nearly surrounded. The only opening in this rim is toward the north 10° east, where it is entirely wanting. This ridge is about three-fourths of a mile distant from the central mass. Its main axis runs about north and south. The intervening space is occupied by a dark valley, shaded with Norway pines. It is very difficult, and in many cases impossible, to pass from the ridge to the centre across this gorge, the rock rising sheer up on nearly all sides about the central mass." The main mass has not a distinct basaltic structure, but it is cut by jointage planes that are in three systems, viz: one series runs about east and west, the individual planes being about ten inches apart, or closer; another series runs northeast and southwest, the planes being four feet apart and having their tops tipped toward the south-



Heeng-ya-kaga peak. A sketch made by N. H. WINCHELL in August, 1874.

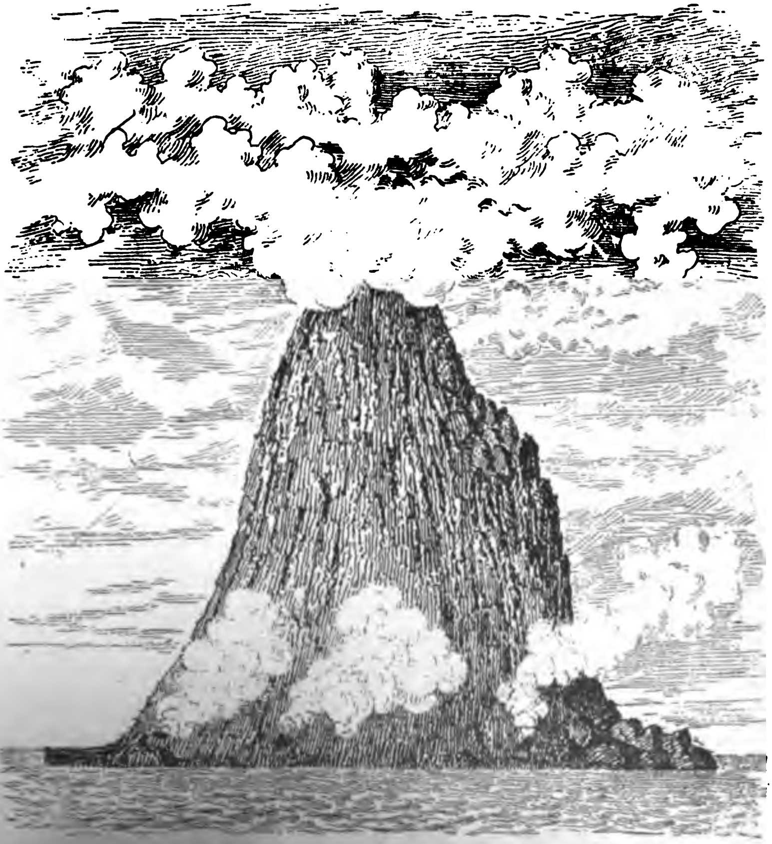
* Report of a reconnaissance of the Black Hills of Dakota made in the summer of 1874, by WILLIAM LUDLOW. Appendix PP. of the Annual Report of the Chief of Engineers for 1875, p. 37.

east about 10°; while a third runs perpendicular to the last and has its tops inclined toward the northeast about 10°. These larger divisions of the rock cause, on being weathered, the columnar structure seen all about the sides of the central mass. There is, besides, on the western side of the central mass, a fourth system of joints that slope downward toward the west at an angle of about 45°, which gives the whole mass at that point the appearance of being a heavy bedded upheaved sedimentary rock. In general, the central mass has a structure that implies greater pressure on the western side with a tendency at the top to curvature toward the east. It may be due to a confused or interrupted basaltic jointage produced in cooling gradually, and while yet in slow upward movement. The top of this central mass therefore may have presented originally a vertical or overhanging face on its eastern side. The hight of Heeng-ya-kagá is about the same as Bear butte.

Bogoslof island, in the Aleutian series, is a volcanic cone or peak which apparently belongs to the same category. Two views of this are presented in plate XXI. These are taken from *Science,* March 7, 1884, where is an account of this island and its changes within historic time, by professor J. E. Hilgard, superintendent of the United States coast and geodetic survey, written by George Davidson. The upper view represents it in 1768 and 1769. In 1778 captain Cook saw it, and says that it was an elevated rock which appeared like a tower, rising above the surface of the ocean. He judged of its steepness below the surface of the sea by the fact that the waves, which were running high, broke nowhere but against its sides. This island seems to have been destroyed, perhaps by the waves, and to have risen again later at a slightly different place, one authority saying that it rose anew from the sea in the early part of May, 1796. The hight of the original rock is not certainly known, but has been given at 400 feet, 600 feet and at 840 feet, the last by a Russian navigator. Professor Davidson quotes the following from a work by Veniaminoff:

"Before the island appeared above the sea there had been witnessed, for a long time in that spot, a column of smoke. On the 8th of May, after a strong subterranean noise, with the wind fresh from the northwest, the new, small black islet became visible through the fog; and from the summit great flames shot forth. At the same time there was a great earthquake in the mountains on the northwest part of Umnak

BOGOSLOFF ISLAND, DISTANT TEN MILES, AS SEEN BY KRENITZEN AND LEVASHEFF, 1768–69.



THE NEW VOLCANIC ISLAND OF BOGOSLOFF AS SEEN SEPTEMBER–OCTOBER, 1883.

island, accompanied by a great noise like the cannonading of heavy guns; and the next day the flames and the earthquake continued. The flames and smoke were seen for a long time. Many masses of pumice stone were ejected on the first appearance of the island."

Professor Davidson adds: "At that time it was, perhaps, only one-quarter the size of its present dimensions; and it increased in size, growing higher, and breaking down at the same time on all sides. Finally, about 1823, it seemed to have become unchangeable. Until it ceased to increase in size it was hot, as well as the sea water around it; while smoke and steam rose from it continuously." The lower figure in plate XXI shows the new island as represented by Davidson. It was larger than the original island. It was more or less enveloped in steam and a "black smoke issuing from it as if tar were burning." * * * "The sides are very steep; and, apparently it has arisen from the depths without developing outlying dangers, because with a heavy swell running, no breakers were seen. It rises very steeply with a rough ogee curve." This island is about half a mile north-northwest of the old one, and about 1000 feet high.

According to W. H. Dall there are other Alentian islands of exactly similar origin, notably Koningi and Kastochi, and Pinnacle island near St. Matthew island. Of some of these he gives profile sketches. *Science*, Jan. 25, 1884, p. 92).

In the western part of the United States are numerous peaks of volcanic rock that have been described as volcanic *necks* and *plugs*. How many of these can be certainly included under the term pelélith it is impossible to state. The new fact of the formation of a volcanic plug by the slow ascent of a mass of volcanic rock already solid, from below the crater rim, as at Martinique, renders it necessary to hesitate in ascribing any manner of origin to such volcanic necks as are well known, and to institute fresh examinations with view to comparison with that of Mont Pelé. It has been customary, following Dutton, to infer that volcanic peaks of this nature have simply been uncovered by circumdenudation, involving in some cases the removal from the vicinity and from the surrounding region, embracing sometimes thousands of square miles, a thickness of three or four thousand feet of the sedimentary strata. Not to mention the difficulties that arise in some places in the effort to apply such a theory, it may be asked whether there are not indications in the conditions surrounding these volcanic necks that allow or require that such necks were also thrust upward in a solid, or at least semi-plastic, condition from some depth below. Does not the vertically columnar structure exclude the idea of cooling from the sides of a fissure or pipe? May not such vertically columnar necks be the deeper portions of non-columnar original peléliths which moved upward originally in the same manner as the peak at Mont Pelé. It is apparent that the pelélith must graduate downward into less and less solid igneous rock and that such rock in slowly cooling would not only not be holocrystalline, but would become structurally basaltic in a direction parallel to that in which its heat departed, i.e., toward the mouth of the crater. If the slow extrusion continued such columnar rock would finally appear above the crater and might be thrust upward to a considerable hight, and might stand long after the upper non-columnar, or less columnar, summit had decayed and disappeared. The surroundings and structure of the peak of Mt. Taylor, in New Mexico, seem to allow of such explanation,* although the subordinate peaks, at a much lower level, have doubtless been uncovered as explained by captain C. E. Dutton.

Another beautifully columnar volcanic neck is that of Mato Teepee in South Dakota. It stands in the valley of the Belle Fourche, about 55 miles in an air line northwest of Deadwood. It rises 1126 feet above the river.† It is a great rectangular obelisk of trachyte with a columnar structure, giving it a vertically striated appearance, as shown by plate XXII. It rises 625 feet about perpendicular from its base. It has been described by professor I. C. Russell in the *Journal of Geology*, vol. 4, p. 31, who gives abundant evidence that as it appears at the present time it has been brought to light by the removal of sedimentary strata in the midst of which it rises, 1500 feet of which have been eroded. He gives, however, no sufficient evidence that this "plutonic plug" did not terminate in an active volcano. Its date was perhaps mid-Cretaceous, but even if it were mid-Tertiary, the surface products of such a volcano would long since have disappeared under the vicissitudes of such vast erosion as he shows has taken place in the valley of

* Mt. Taylor and the Zuni plateau. C. E. DUTTON. *Sixth Annual Report of the United Geological Survey.*

† Geology of the Black Hills. HENRY NEWTON.

Mato Teepee, S. Dak.

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the Belle Fourche. Hence it is not impossible that Mato Teepee represents the deeper portions of what may have terminated originally by a pelélith like that of Martinique.

The vertical basaltic columns seen in the plate turn outward all about their bases so as to terminate against the deeper interior walls of the pipe in which they were originally enclosed. This indicates not only that the plug at the time of its cooling was confined in a vertical pipe, but also that its heat escaped into its walls, but primarily toward the crater. The curved columns have successively fallen off, except near the base, leaving exposed to view only those which run upward in the central part of the mass without such curvature, or which curve outward at greater depth.

It is not necessary to multiply these illustrations of possible pelélitic roots. It is not intended to apply the new term to other rock masses than those that can be shown to have ascended bodily above the crater rim of an active volcano; and to suggest that perhaps there are more than have been supposed of the same kind.

[Note.—Since the foregoing was written professor I. C. Russell, has published, in the *American Journal of Science* for April, 1904, a discussion of this subject, and has mentioned several other peaks in the United States that can be referred to this class, viz: the Panum crater, east of lake Mono, in California. This central column in the manner of its formation was understood by professor Russell, and was described by him in 1889 in the 8th Annual Report of the United States Geological Survey; a crater near Pauline lake in the south-central part of Oregon. Professor Russell mentions, in his discussion, the criteria for distinguishing peléliths from volcanic necks and from erosion forms of igneous rocks.]

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On the Structure of the Pteraspidae and Cephalaspidae. By W. PATTEN (*American Naturalist*, vol. 37, no. 444. Dec. 1903).

This paper is a new attempt to prove the arachnid descent of the vertebrates. It is an argument in favor of two distinct propositions,—that the ostracoderms are the ancestors of the vertebrates and that the ostracoderms are derived from the arthropods.

For complete proof of any phylogenetic theory, the arguments from embryology and from comparative anatomy must be supported by palaeontology. Professor Patten's theory has in its favor the fact that his ancestral forms had hard shells and hence are preserved, hence complete proof or disproof should be only a matter of time and work. None of the other current theories of vertebrate origin—(Annelid; Enteropneusta; Prosopygia; Nemertine)—can ever receive complete demonstration, since the animals are soft bodied, and not preserved as fossils. Nevertheless professor Patten has not yet proved either of his two propositions.

That the general affinity of the ostracoderms is with the vertebrates has been recognized since they were first described; yet the essential features of vertebrate organization—(the presence at some stage of development of gill slits, notochord, and dorsal nerve tube)—have never been definitely made out. Their remarkable resemblance to trilobites has also been frequently commented upon. Professor Patten takes up the various anatomical features of Pteraspis and of Cephalaspis, and draws a comparison between them and analogous structures in arthropods, finding many points of similarity.

But one point which professor Patten entirely ignores in his researches is the fact that the sharks are the oldest vertebrates, being recognized as ancestral not only to higher fishes but to the land vertebrates as well. There is a wide break between Cephalaspis and Cladoselache, and it appears impossible to derive the shark line, which is undoubtedly ancestral to higher forms, from an ostracoderm ancestor. Whatever their systematic position, the ostracoderms appear to be, like Palaeospondylus and the arthrodires, a side branch from the early vertebrate stem and not a stage through which the whole vertebrate phylum passed.

Professor Patten's paper consists of a very carefully worked out description of the fossils; of a review of the authoritative opinions of former observers; and of a statement of his own opinion. I. H. O.

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Evidence of the agency of water in the distribution of the loess in the Missouri valley. (Am. Geol., vol. 33, p. 205, Apr., 1904.)

CORRESPONDENCE.

A NEW EXPOSURE OF SERPENTINE AT SYRACUSE, N. Y. That serpentine occurs at Syracuse, N. Y., is quite widely known among geologists, inasmuch as reference has often been made to it. As early as 1839, we find that Vanuxem mentioned it in his "Third Annual Report," and again in 1842 in his "Report on the Third Geological District." Beck in the "Mineralogy of New York," 1842, calls attention to the occurrence of serpentine at Syracuse. T. S. Hunt also studied it, and in 1858* published an analysis of the rock. In 1887, G. H. Williams† published a very comprehensive paper on this serpentine in which, for

* *American Journal of Science*, vol. xxvi, (2), p. 237, 1858.
† " " " vol. xxxiv, (3), pp. 137-145, 1887.

the first time, the igneous character of the rock was shown. The investigators, mentioned thus far, all studied the rock as it occurs at the Green street exposure, where it was first observed by Vanuxem.

Since the publication of Williams's paper in 1887, serpentine has also been observed to occur in several places somewhat to the northwest of the Green street locality. In 1901, during the construction of the large Butternut street trunk sewer, serpentine was encountered between Butternut and Highland streets, about 150 to 200 feet north of Farmer street. The cut through the serpentine extended for several hundred feet. It was found to occur also for a considerable distance in Highland street. P. F. Schneider* described this second occurrence in 1902, and C. H. Smyth, Jr.,† investigated the rock as to its petrographical characters.

The rock at the "Butternut and Highland" locality agrees, megascopically, with that of the original (Green street) locality, which is about five-eighths of a mile distant. This agreement in the structure and mineral composition of the rocks of these two localities led Schneider to suggest that there may be some connection between them. He says: "The proximity of these dikes‡ to those at Green street, which is less than a mile away, suggests some underground connection, and inasmuch as their general direction is the same they may be merely a continuation of those dikes. The intervening space has frequently been trenched, and at such times the excavations have been carefully watched for evidences of the dikes without revealing any trace of them."

During the past few months a branch sewer to the Butternut street trunk sewer has been constructed in Griffiths street, about one-fourth of a mile to the northwest of the "Butternut and Highland" locality. Mr. H. B Brewster of the City Engineer's office, who had supervision of the construction of the sewer, called my attention to the character of the rock being thrown out, which on examination proved to be serpentine. The rock was encountered about 100 feet west of Butternut street. The cut through the serpentine is about 70 to 75 feet. It was found at a depth of 5 feet and is covered with drift. Between Butternut street and the serpentine the cut passed through about 30 to 40 feet of Salina shale.

The rock at this new locality is like that from the other two localities, mentioned above, of a dark green color, sometimes almost black, distinctly porphyritic, showing phenocrysts of olivine, weathers easily on exposure to a dark green or yellowish green earth, and in some places has many inclusions. Judging from a megascopic examination of the rock at this Griffiths street exposure, it agrees exactly with that from the other exposures in Highland and Green streets. A detailed report on the microscopic characters will be made later.

As already indicated, Schneider suggested that the "Butternut and Highland" locality might be connected with the exposure in Green street. From the fact that the rocks in these three localities are of

* *American Journal of Science*, vol. xiv, (4), pp. 24-25, 1902.
† " " " vol. xiv, (4), pp. 26-30, 1902.
‡ SCHNEIDER thinks there are two dikes in the vicinity of the "Butternut and Highland" locality.

the same general structure and mineral composition, and also that a straight line connecting the original locality (Green street) with the Griffiths street exposure passes through the centre of the second, as seen in the vicinity of Highland street in 1901, one is of necessity led to believe that these occurrences of serpentine are merely three exposures of one and the same dike, which extends from Green street in a northwesterly direction. The distance between the "Green" and "Griffiths" exposures is about seven-eights of a mile. That the dike has never been exposed between these three localities is due to the fact that excavations between them have not been made to a sufficient depth.

City Engineer Frank J. Schnauber informs me that several other branch sewers are to be constructed within a few months in the vicinity of Griffiths street. The excavations for these, especially the one in Kappesser Ave., across which the dike no doubt extends, will be watched with great interest for new exposures. EDWARD H. KRAUS.

Syracuse High School, March, 1904.

PERSONAL AND SCIENTIFIC NEWS.

PROF. E. M. SHEPARD, of Drury College, Springfield, Mo., recently made a professional visit to Oaxaca, Mexico.

PROFESSOR J. V. LEWIS, of Clemson college, S C., has been appointed professor of geology and mineralogy at Rutgers College, New Brunswick, New Jersey.

DR. H. M. AMI, of the Canadian Geological Survey, has been for some months at Thomasville, Ga., on sick leave absence, but returned to Ottawa in March.

DR. H. FOSTER BAIN, of the United States Geological Survey, delivered a course of lectures on ore deposit at the University of Chicago. The course began February 15th and continued six weeks.

DR. C. W. HAYES, of the United State Geological Survey, gave a course of geological lectures at Johns Hopkins university, Baltimore, involving a discussion of the Appalachian district, and its mountain structure.

THE CURATORSHIP OF THE GEOLOGICAL COLLECTIONS of the Peabody Museum at Yale University, made vacant by the death of professor C. E. Beecher, has been filled temporarily by the appointment of professor L. V. Pirsson.

A SCHOLARSHIP VALUED AT $150.00 has recently been established in the New Mexico School of Mines, open to the best member of the graduating class of each year, desiring to make a special study of mining machinery in the large manufacturing works.

PROFESSOR ALEXANDER N. WINCHELL lectured at the Minnesota School of Mines, April 4, on "Conditions at Butte." He proceeded at once to St. Louis, where he is installing the mining exhibit of the State of Montana at the Louisiana Purchase Exposition.

THE NEW PACIFIC SOCIETY OF MINING ENGINEERS, lately organized at Seattle, has for its first officers Chester F. Lee, president; Milnor Roberts, vice-president; F. C. Newton, recording secretary; P. C. Stoess, corresponding secretary; and C. E. Bogardus, treasurer. These constitute the managing board.

THE NEWBERRY COLLECTION OF FOSSIL FISHES, deposited for many years in the Museum of the Columbia College School of Mines, has been transferred to the American Museum of Natural History, New York, and a special curatorship for fossil fishes has been established, to which Dr. Bashford Dean has been appointed.

DR. LOUIS BEUSHAUSEN, of the Landesanstalt, Berlin, and professor of geology in the Bergakademie at that place, died February 21, at the age of 48 years. Professor Beushausen's work on paleontology, stratigraphy and tectonics of the Hartz mountains was distinguished for its precision and to paleontologists his fine monograph of the Devonic Pelecypoda of Germany is well known.

MORE OIL WELLS WERE COMPLETED IN 1903, says the Oil City *Derrick*, than during any previous year in the history of the petroleum industry. The total for the Pennsylvania and Trenton rock fields was 16,232, which includes 2,889 which were classed as dusters or dry holes. In the two states producing Lima oil 7,758 wells were completed, and of these only 675, or only about 9 per cent, got into the duster list. The increase in wells completed as compared with the record for 1902 was 2,050, or nearly 14 per cent. In addition to the developments in the eastern oil fields, considerable activity has prevailed in the petroleum regions of Kentucky and Kansas. Estimating 500 for the wells completed during the year in the former state and 1,500 in the latter, will give a grand total of 18,232. When the operations in California, Texas and other states are considered it will be seen that the search for oil is being conducted on an unprecedented scale and that the petroleum industry is contributing a very large share to the general prosperity of the country.

UNITED STATES GEOLOGICAL SURVEY.

Among the recently issued topographic maps is that of Blue Hill, Maine.

"Contributions to economic geology, 1903," is the title of Bulletin No. 225, which is now ready for distribution. This publication has the same object as Bulletin No. 213, entitled "Contributions to economic geology, 1902," which met with such a hearty reception both from mining men and from geologists.

Dr. C. C. Martin reports coal of good quality as occurring in Alaska from twelve to twenty-five miles inland from Controller bay, in the valley of Bering river. The coal occurs in several seams, one of which is reported to be twenty feet in thickness. Much of the coal is a hard bituminous variety approaching anthracite, and in one locality, at least, is a seam of natural coke. Details concerning this district are given in Bulletin 225.

The Patoka folio (No. 105), by M. L. Fuller and F. G. Clapp, is now ready for distribution. This folio includes parts of southwestern Indiana and southeastern Illinois

The Nampa (Idaho) folio, No. 103, by Waldemar Lindgren and N. F. Drake, has recently been published.

In a paper read before the New York Academy of Sciences, Dr. Charles P. Berkey, of Columbia University, discussed "A Geological Reconnaissance of the Uintah Reservation, southeastern Utah." He said in part: "Observations made in connection with other lines of work last summer have shown an erosion unconformity in the Carboniferous strata of the western Uintahs. It is marked on the south side of the range by an unevenness in the floor and a development of conglomerate the pebbles of which are of the preceding formation. The break comes just above the chief limestone member of the series.

"The junction between the great basal quartzyte of the United States and the overlying strata is marked by a fault in this region with sufficient throw to bring two quartzyte beds together on the higher plateaus and be easily overlooked. This makes it impossible to confirm Powell's unconformity at the top of the quartzyte as described by him in the eastern Uintahs.

"The discovery, however, of the Carboniferous erosion interval a little higher in the series throws additional doubt upon the assumed Carboniferous age of the great quartzyte member. Allowing the break to cut out a part of the 'Wasatch' limestone and the 'Weber' quartzyte, as developed in the Wasatch uplift, the lithologic succession is satisfied better by assuming Cambrian age for the lowest member in the Uintahs.

"There is no other break to the close of the Cretaceous. A progressive unconformity, which increases in value against the flanks of the range marks the development of Tertiary sediments in the Duchesne valley. A conglomerate formed in progressive overlap from the stream valleys to the higher mountain tops of the flanks, has peculiar characters near the limestone belt, on account of which King called it 'Wyoming' conglomerate. These characters are too local to give it the assumed stratigraphic importance, while the flanking conglomerates are really of great range."

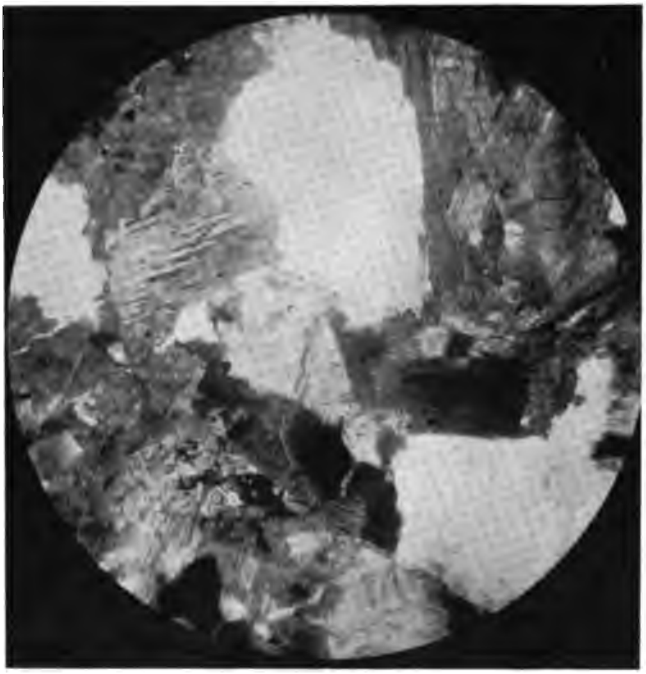

FIG. 1. Thin Section of Kersantyte as seen under a microscope between crossed nicols × 35 (Rossland 40).

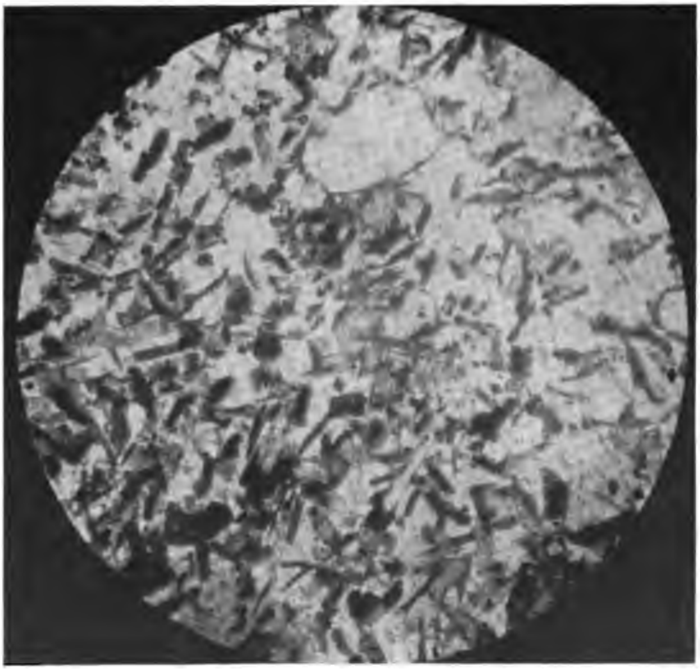

FIG. 2. Thin Section of Kersantyte as seen under a microscope between crossed nicols × 35 (Rossland 6).

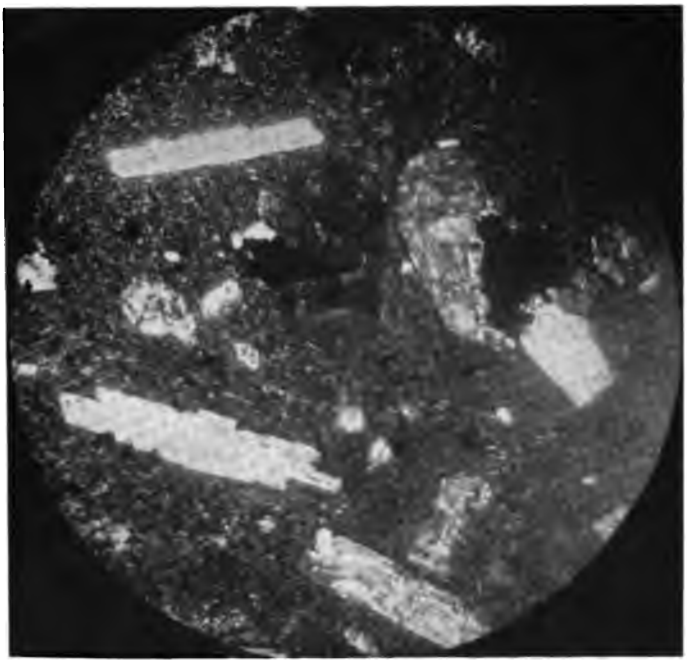

Fig. 3. Thin Section of Camptonyte as seen under a microscope between crossed nicols × 35 (Rossland 105).

Fig. 4. Thin Section of Camptonyte as seen under a microscope between crossed nicols × 35 (Rossland 100).

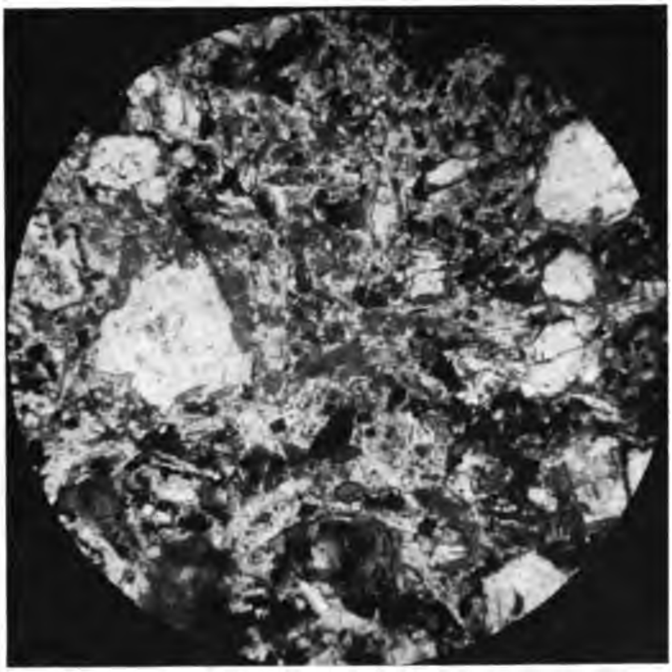

FIG. 5. Thin Section of Angite-Camptonyte as seen under a microscope between crossed nicols × 35 (Rossland 9).

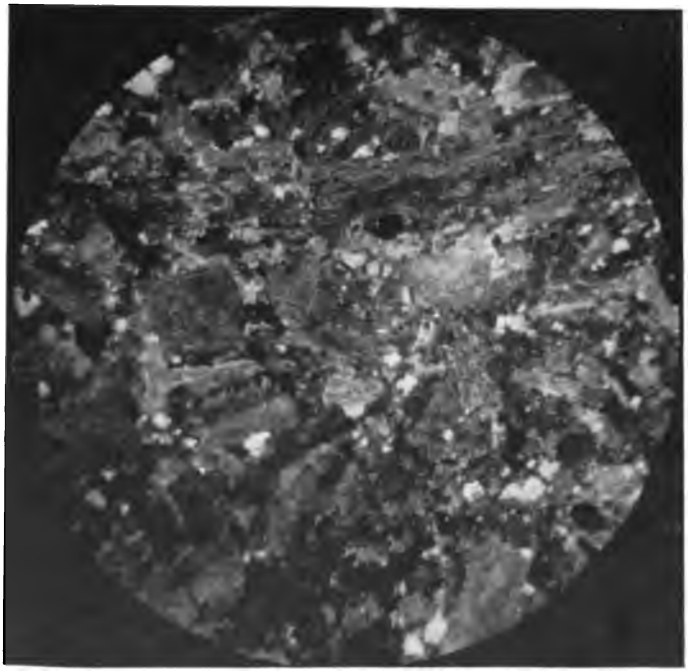

FIG. 6. Thin Section of Kersantyte-Camptonyte as seen under a microscope between nicols × 35 (Rossland 49).

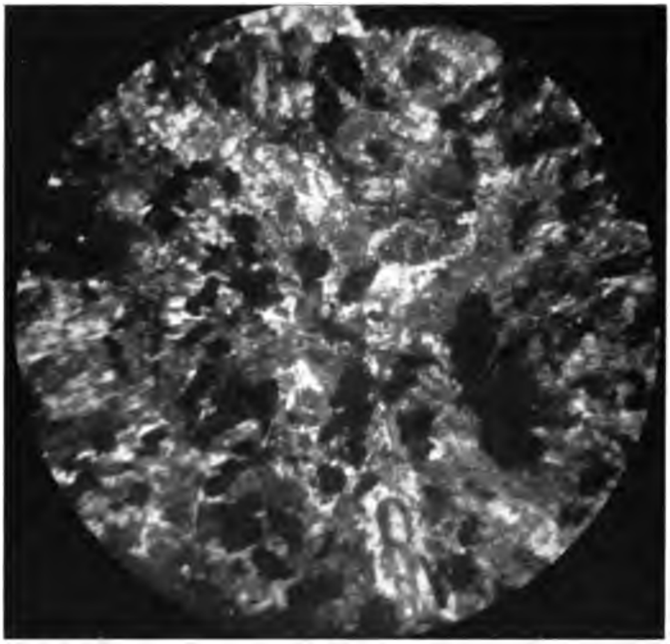

FIG. 7. Thin Section of Minette as seen under a microscope between crossed nicols × 35 (Rossland 19).

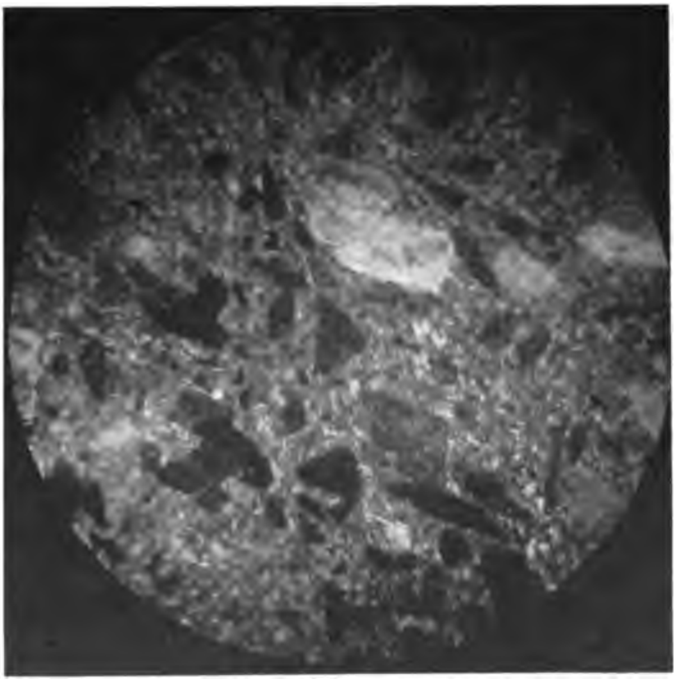

FIG. 8. Thin Section of Vogesyte as seen under a microscope between crossed nicols × 35 (Rossland 102).

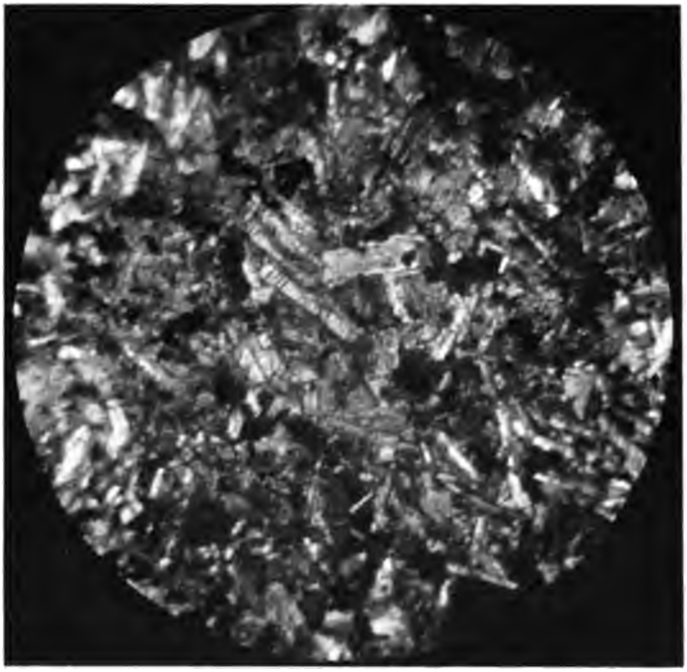

Fig. 9. Thin Section of Syenyte-Monzonyte as seen under a microscope between crossed nicols × 35 (Rossland 27).

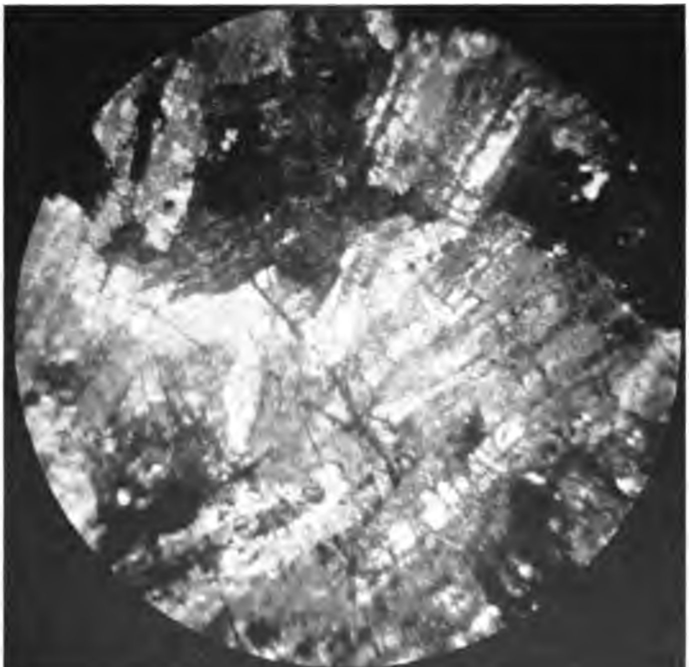

Fig. 10. Thin Section of Syenyte-Porphyry as seen under a microscope between crossed nicols × 35 (Rossland 57).

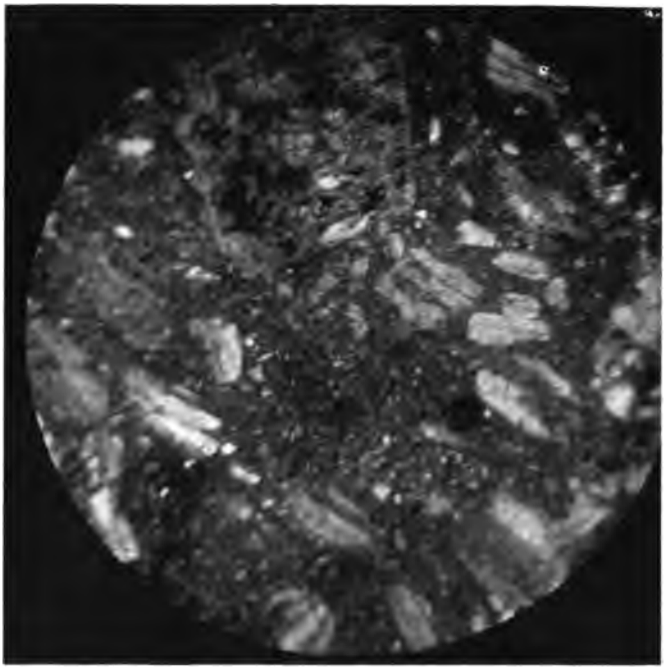

FIG. 11. Thin Secelon of Dioryte-Porphyry as seen under a microscope between crossed nicols × 35 (Rossland 13).

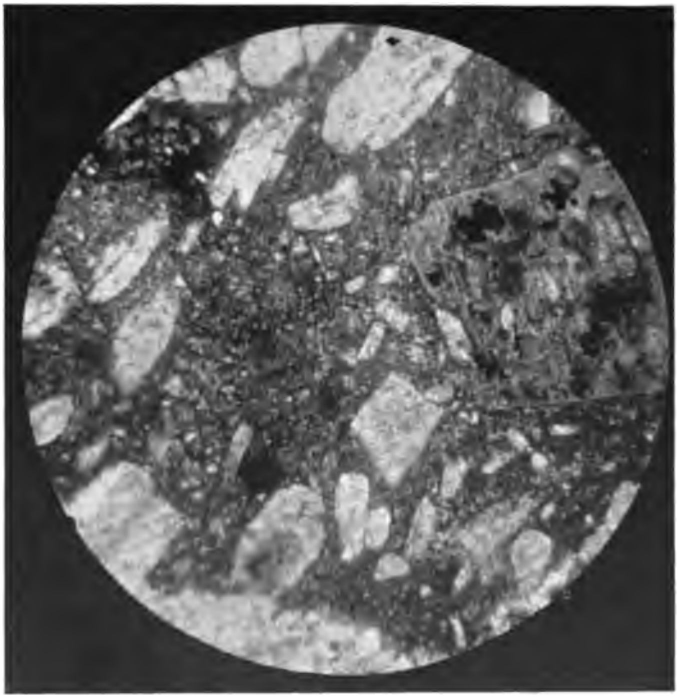

FIG. 12. Thin Section of Dioryte-Porphyry as seen under a microscope in ordinary light (Rossland 13).

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ON THE LAMPROPHYRES AND ASSOCIATED IGNEOUS ROCKS OF THE ROSSLAND MINING DISTRICT, BRITISH COLUMBIA.*

By WILLIAM BURTON BARBER, Alameda, Cal.

PLATES XXIII-XXVIII.

CONTENTS.

Introducton.

The entire area of the Rossland Mining District is made up almost entirely of eruptive rocks. The main body of this eruptive is dioryte. Little or no sedimentary deposits are found in the district.†

The great mass of dioryte was strained from north to south, opening up a nearly vertical and often parallel system of fissures. These fissures have a general easterly and westerly

*The writer is indebted to Dr. J. P. Smith of Stanford University for assistance and advice.

†The notes on the general geology of this district are taken from the testimony of Mr. Clarence King in the law suit of the Iron Mask Gold Mining Company vs. Center Star Mining and Smelting Company before the Supreme Court of British Columbia, April, 1899, pp. 6-10.

direction and were immediately filled by intrusive dikes. There is consequently along these dikes much crushed and broken ground, and it is in this crushed area that the mineral deposits of the district are located.

The lamprophyres as well as most of the associated rocks are found between the 700 foot and 900 foot levels of these mines. All are extremely fresh and show little alteration to the naked eye.

The igneous rocks described in this paper occur as dikes and stocks in the War Eagle, Josie, Iron Mask, Le Roi, and Le Roi No. 1 mines, and were collected by Mr. E. A. Strout, a mining engineer of Rossland. I am indebted to Mr. Strout for the notes on the geologic occurrence of these rocks. They represent all the sorts of rock observed in an underground survey of the above mentioned mines.*

The numbers corresponding to Mr. Strout's type set of rocks, now deposited in the geologic collection at Stanford University, are given with each description for convenience of reference.

LAMPROPHYRES.

Kersantyte.—This rock, (40 Rossland) Fig. 1, occurs in a ninety-foot dike at the 700 foot level of the Josie mine, and is a black, fine grained rock with large crystals of biotite. It is rich in mica and has some hornblende, feldspar and magnetite.

The biotite, present in great abundance, is brown in color and shows the characteristic wavy cleavage. In some cases it has formed secondary muscovite, giving up its iron as magnetite. It is strongly pleochroic, changing from light to dark brown and has a maximum size of 1.2 mm. in length and .5 mm. in width.

The muscovite is perfectly clear, has very fine parallel cleavage, and is highly colored in polarized light.

The feldspar which is in the ratio of about two to three to the biotite is largely labradorite, showing polysynthetic twinning, zonal extinction, and extinction angles varying between 21° and 28°. It is weathered to calcite in some instances.

Hornblende is present chiefly as phenocrysts with a rather deep color and with pleochroism from light to dark green. The

*I am indebted to Mr. H. S. Coe, a mining engineer of Craig, Colorado, for the preparation of a number of slides and for assistance in the description of some of the rocks.

crystals are primary, contain inclusions of plagioclase, and have a distinct prismatic cleavage of about 124°; they have a maximum length of 2.5 mm., and a maximum width of .4 mm.

In the network of crystals forming the ground mass, aside from biotite and feldspar, are small crystals of magnetite and pyrite, needles of apatite, and calcite and chlorite as weathering products.

Two dark, fine grained kersantyte dikes (6, 34, and 107 Rossland) were seen; one two feet wide occurs at the 800 foot level and the other eleven feet wide occurs at the 700 foot level of the War Eagle mine.

Thin sections, Fig. 2, show a fine grained holocrystalline structure containing more biotite than the preceding rock, but the crystals are much finer grained. A large amount of magnetite is present, and the feldspars are not so clear as in the Josie dike, but are badly kaolinized.

Camptonyte.—This type of rock (112 Rossland) is a lamprophyre occurring in a small dike at the 900 foot level in the War Eagle mine. It is a medium fine-grained rock, having hornblende as the preponderant consituent; it contains feldspar, which is chiefly plagioclase, calcite, chlorite, biotite, and some nepheline.

In thin sections the hornblende is seen to be both primary and secondary, and exhibits strong pleochroism from light to dark green; its maximum size is .6 mm. in length and .25 mm. in width. The secondary hornblende, uralite, has been altered from primary diopside, almost all of which has been changed to hornblende.

The feldspar is chiefly plagioclase with a few crystals of orthoclase, the plagioclase being principally labradorite, with polysynthetic twinning after the albite law.

They are generally lath-shaped and some exhibit zonal structure; they have a maximum length of .4 mm. and a maximum width of .2 mm.; a few, which are probably oligoclase, have small extinction angles and little or no polysynthetic twinning.

There is a small amount of magnetite in these rocks and some pyrite. Biotite is present in small quantities and shows its distinct form and strong pleochroism.

There is a small amount of nepheline present; it is a clear mineral with no relief and with a low interference color in thin sections. These crystals have a prismatic shape, parallel extinction, and an average length of .1 mm. and an average width of .05 mm.

Calcite, serpentine and chlorite are present as weathering products, and needles of apatite can be detected in the ground mass.

Camptonytes were found in the Josie mine near the Josie dike at the 600 foot level. The specimens from this dike showed olivine in large crystals, most of which is changed to serpentine. The rock also contains more biotite than in the preceding dike.

At the 700 foot level of the War Eagle mine is a dike of camptonyte, Fig. 3, (105, 106 and 108 Rossland); its composition is much the same as that of the preceding rock, but the groundmass is decidedly porphyritic and the crystals of augite and of plagioclase are much larger. The groundmass is composed of plagioclase, augite, hornblende, biotite, nepheline and magnetite.

Another dike of camptonyte, Fig 4, (100 and 103 Rossland) was found at the 700 foot and 900 foot levels of the War Eagle mine near the new shaft. This is a ten-foot dike and differs from the smaller dike last described in the War Eagle mine in being of darker color, and finer grain. It contains more hornblende than the preceding and most of this is primary. Very little diopside is noted, and the feldspars and biotites are smaller. No nepheline was found.

Augite Camptonyte.—At the 700 foot level of the Le Roi mine is a 40-foot dike (9 Rossland) which differs from the preceding type in having the monoclinic pyroxene predominant over the hornblende.

In thin sections, Fig. 5, the rock shows lamprophyric structure with phenocrysts of pyroxene in a ground mass composed largely of augite, feldspar, biotite, apatite, hornblende, and magnetite, and weathering products as calcite and chlorite. The predominant mineral, augite, is brownish in color and appears in two generations; those of the first generation occur only as phenocrysts, are somewhat weathered and contain inclusions; they show a light brown color with slight pleochroism and have a maximum length of 1.4 mm., and a maximum width of 1. mm., those of the second generation occur only in the ground mass, are quite fresh, and have a maximum width of .05 mm.

The feldspar is largely labradorite, having an extinction angle varying from 21° to 28° and showing twinning after the albite law; much of the plagioclase is kaolinized; its maximum size is 1.2 mm. in length and .2 mm. in width. Some of the plagioclase is altered around the edge to calcite, while a number of crystals which are oligoclase and orthoclase show little or no twinning and have nearly parallel extinction.

Hornblende is present chiefly as an alteration product of the augite. The biotite is in various sized crystals up to 1 mm. in length, and the quartz shows corrosion around the edges.

A small augite camptonyte dike (61 Rossland) was also found at the 700 foot level in the War Eagle mine. The rock is darker than the preceding, contains less biotite and feldspar, and greater abundance of pyroxene, which is diopside instead of augite; the crystals are smaller and the feldspars are not so badly kaolinized.

TRANSITIONAL ROCKS.

Associated with these rocks which are true kersantytes, or camptonytes, are various gradations from one type into the other. They are alike in having a ground mass with a basic plagioclase predominating over the acid feldspars and quartz; some of the camptonytes, however, while having the necessary constituents, augite and hornblende, have almost an equal amount of biotite, which would class them not as camptonytes or kersantytes, but midway between these two types.

The following is a description of a rock of the camptonyte type (25 and 49 Rossland) but containing considerable biotite, and yet so near in structure to a diabase that it might well be classed as such except that it appears to be too acid for that group. It is fine grained and occurs as a two-foot dike in the ninety-foot Josie dike, and having the same strike.

In thin section, Fig. 6, the rock is holocrystalline, with a few large lath-shaped plagioclase feldspars and augites that are altered into hornblende, embedded in a fine grained crystalline groundmass. The groundmass consists chiefly of plagioclase, biotite, and magnetite, with numerous patches of calcite from the weathered feldspars.

Plagioclase feldspar is the dominant mineral in the section; it is idiomorphic and shows polysynthetic twinning after the albite law. From a number of measurements taken upon the twinning face, the extinction angle of one set of crystals has an average of 5° indicating oligoclase, while measurements taken on the twinning face of another set of crystals vary from 21° to 28° indicating labradorite.

Oligoclase is more abundant than the labradorite; the crystals have a maximum size of .5 mm. in length and .2 mm. in width. The plagioclase shows alteration in some cases to calcite. A few crystals of quartz and orthoclase were noted.

Biotite is seen surrounding the feldspar crystals and is weathered in many cases to green chlorite. Calcite and epidote occur in irregular aggregates from alteration of the feldspars.

There is a small amount of augite in the rock somewhat altered to hornblende, and showing a maximum length of .7 mm. and a maximum width of .4 mm.

Minette.—The rock referred to under this class of lamprophyres (19 Rossland) occurs as a 20 foot dike at the 900 foot level in the Josie and Le Roi mines, and is a medium grained rock, of a dark gray color, with crystals of biotite and greenish white fibres of natrolite. These minerals are imbedded in a grayish groundmass which upon microscopical examination proves to be chiefly feldspar, the orthoclase being dominant over the plagioclase.

In a thin section, Fig. 7, the rock is porphyritic with phenocrysts of biotite in considerable quantities, and a smaller amount of monoclinic pyroxene. The ground mass is composed largely of orthoclase and plagioclase; the orthoclase is greatly in excess of the plagioclase.

The biotite is idiomorphic and occurs in large phenocrysts; it is very pleochroic, changing from dark reddish brown to light brown; the crystals reach a maximum length of .75 mm.

The monoclinic pyroxene is diopside; it has a pale greenish color with slight pleochroism and occurs chiefly in long phenocrysts; it has a maximum length of .5 mm. and a maximum width of .1 mm.

The feldspars occur in the ground mass; orthoclase is irregular in shape and twinned after the Carlsbad law. A number of readings of the extinction angle on the twinning face of the plagioclase crystals varied from 0° to 5° indicating the acid soda plagioclase, oligoclase; these have distinct cleavage, show polysynthetic twinning after the albite law, and have a maximum length of .35 mm.

Amphibole (hornblende) occurs in the ground mass as an alteration from diopside (uralite). A small quantity of chlorite is shown in the section, due to weathering of the biotite. Calcite occurs as a weathering product from plagioclase. Magnetite and pyrite are distributed abundantly in small crystals. Apatite occurs in the form of elongated or needle-like crystals, widely distributed throughout the ground mass.

Aggregates of colorless crystal fibres, somewhat kaolinized and possessing a spherulitic structure are noted. These crystals, which are probably natrolite, are weakly doubly refracting having an interference color about yellow, of the first order, in rather thick slides, and occurs as an alternation product of plagioclase.

Vogesyte.—In a railroad cut near the workings of the Le Roi mine, is a medium grained rock (18 Rossland) with a gray color, showing large phenocrysts of monoclinic pyroxene and amphibole which have a maximum length of 1.25 mm., and can be detected readily with the naked eye; the ferro-magnesium minerals lie in a groundmass of feldspar.

In thin section this rock is seen to be a lamprophyre with phenocrysts of pyroxene and of hornblende, the hornblende being in greater abundance than the pyroxene. The spaces between the ferro-magnesium minerals are filled with alkali feldspars in excess over plagioclase, apatite, magnetite, and pyrite.

The amphibole is idiomorphic, occurring almost entirely as phenocrysts; it is of the basaltic (brown) hornblende type, is chiefly primary, and has a maximum size of 1.25 mm. in length and .4 mm. in width. In sections parallel to the C axis, the hornblende shows parallel cleavage, and strong absorption parallel to the direction of elongation and cleavage. The crystals show frequent twinning, and exhibit strong pleochroism from dark to light brown; some of the hornblende is secondary, being derived from alteration of the pyroxenes.

The monoclinic pyroxene is diopside; it occurs almost entirely as phenocrysts, though in not nearly such great abundance as the hornblende; it is light green with faint pleochroism; the larger crystals are somewhat altered, while the smaller ones are quite fresh.

The ground mass of this rock is made up almost entirely of anhedrons of feldspar interwoven around the pyroxene and hornblende, with crystals of magnetite and apatite filling the inter-spaces. Orthoclase is much more abundant than the plagioclase; it averages .05 mm. in diameter. The plagioclase is banded and a number of readings of the extinction angle on the twinning faces gives an average of 5°, indicating oligoclase.

Apatite is present in the ground mass in numerous clear, colorless needles.

The country rock (102 Rossland) at the 700 foot level of the War Eagle mine is a vogesyte, Fig. 8. It closely resembles the preceding rock, but has in addition large phenocrysts of plagioclase feldspar. The feldspar in the groundmass is almost entirely orthoclase.

GRANULAR ROCKS.

Monzonyte.—This augite syenyte, or monzonyte, (59 Rossland) is a massive rock found in the Iron Mask mine, and it is a coarse grained, light colored rock showing feldspar, biotite, augite, and hornblende to the naked eye. It is intermediate between syenyte and dioryte.

In thin section the rock is granular with large crystals of feldspar and augite, having a maximum length of 1 cm. Orthoclase is abundant; it has a maximum length of 2 mm. and a maximum width of 1 mm.; it is idiomorphic and twins after the Carlsbad law, the twinning boundary being bent or jagged. Inclusions of plagioclase are common; these have an average length of .4 mm. and a width of .3 mm.

There is much plagioclase present in long lath-shaped crystals; these are smaller than the orthoclase, are idiomorphic, show polysynthetic twinning, and some show zonal structure. A number of readings of the extinction angle on the twinning face ranged from 1° to 5°, indicating oligoclase. The crystals have a maximum length of .5 mm. and a width of .2 mm.

Small quantities of biotite with some inclusions of feldspar are noted; it is idiomorphic and has a distinct pleochroism from dark to light brown. The crystals have an average width of .3 mm. in cross section.

The monoclinic pyroxene present is idiomorphic, and contains inclusions of feldspar; it is diopside and is changed around the borders to hornblende; the maximum size of the crystals is 1 cm. in length and 1 mm. in width.

Basic Monzonyte.—The monzonyte (53 Rossland) herein described as a medium-grained, gray, massive rock occurring at the 300 foot level of Le Roi No. 1 mine; it is rather fine-grained with phenocrysts of amphibole, pyrite, and biotite, which may be detected with the naked eye.

In thin sections the rock is seen to be holocrystalline, and composed largely of feldspar and hornblende. The hornblende is hypidiomorphic, with characteristic cleavage and with pleochroism from brown to green; the maximum length of the crystals is .5 mm. and the maximum width is .2 mm.

The plagioclase feldspar occurs in lath-shaped crysfals, is invariably twinned, and shows the idiomorphic character quite distinctly; it is chiefly oligoclase, as shown by its having very small extinction angles on the albite twins. It is somewhat kaolinized and contains inclusions of hornblende.

The small amount of biotite present shows crushing. Orthoclase and magnetite are also present in small quantities.

Syenyte-Monzonyte.—The country rock (27 Rossland) of the Le Roi mine is not a true syenyte, but approaches a monzonyte. It is fine grained and of a light gray color.

In thin sections, Fig. 9, the rock is holocrystalline, is granular and more acid than the monzonyte from the Iron Mask mine. The amphibole is idiomorphic, with the strong pleochroism, changing from almost colorless with a slight greenish tint to a deep green color; its maximum length is 1. 4 mm. and the maximum width is .35 mm. Orthoclase is noted in small irregular shaped crystals which are frequently twinned according to the Carlsbad law; the maximum length is .4 mm. and the maximum width is .15 mm.

The plagioclase is idiomorphic and considerably weathered to calcite; the crystals show polysynthetic twinning, and a number of readings of the extinction angle on the twinning face varied from 0° to 5°, indicating the presence of the soda-lime feldspar, oligoclase; their maximum length is 1.7 mm. and their width is 4.5 mm.

Biotite is noted in small quantities. A small amount of quartz is also present; the crystals are clear, irregular in shape, have a low relief, with low interference colors and no cleavage. The section also shows a small amount of augite, that has been altered to hornblende, and some magnetite.

Syenyte Dike.—On the 200 foot level of the Le Roi No. 1 mine is a dike of syenyte (55 Rossland) about ten feet wide; it is a light gray rock with small phenocrysts of hornblende in a ground mass which proves to be feldspar under the microscope.

In thin sections the hornblende is hypidiomorphic, with a maximum length of .4 mm. and a maximum width of .1 mm. It is strongly pleochroic, changing in color from dark to brownish green and shows no zonal structure.

Monoclinic pyroxene (diopside) is seen in small crystals showing the results of crushing; their average length is .25mm. and an average width is .07 mm.; it has a high relief and interference colors higher than those of the hornblende.

The groundmass of the syenyte is made up of feldspar; this is very largely orthoclase, some showing twinning according to the Carlsbad law; the plagioclase crystals have almost parallel extinction, indicating oligoclase.

Quartz is present in small quantities as anhedrons. Grains of magnetite and pyrite are also present.

Syenyte Porphyry.—This porphyritic rock (57 Rossland) is finer grained than the monzonyte of the Iron Mask mine, and occurs as a 60-foot dike in the Le Roi No. 1 mine. It is light colored, and shows phenocrysts of biotite, hornblende, and feldspar in a whitish groundmass which proves under the microscope to be feldspar.

In a thin section, Fig. 10, the rock is panidiomorphic, with a few large crystals of feldspar, biotite, and hornblende in a groundmass composed of fine crystals of biotite, feldspar and augite.

Orthoclase and plagicclase are almost evenly divided in numbers; orthoclase shows alteration to kaolin, while the plagioclase is somewhat changed to kaolin and calcite; the plagioclase is oligoclase and shows polysynthetic twinning; the average size of these crystals is about 4 mm. in length and about 1.7 mm. in width.

The hornblende is idiomorphic and has two generations of crystals; those of the first generation have a maximum length of 1mm. and a maximum width of .3mm., and are strongly pleochroic, changing from green to brownish; those of the second generation have an average length of .2 mm. and an average width of .1 mm.

Pyrite, biotite, quartz and magnetite are present in small quantities.

Hornblende Dioryte.—A part of the country rock on the footwall side of the ore vein at the 900 foot level in the Le Roi mine is a hard, coarse grained, light colored dioryte (3 Rossland). It has a granular, holocrystalline structure with large crystals of amphibole and biotite which can be easily detected with the naked eye. A microscopical examination of the rock shows the white mass to be feldspar, many of the crystals showing their true form.

A thin section of this rock shows the predominant mineral to be idiomorphic hornblende occurring in crystals having a maximum length of 1.7 mm., and a maximum width of 1 mm.; some of this is secondary (uralite) being altered from augite.

Plagioclase occurs in lath-shaped crystals, polysynthetically twinned after the albite law, containing numerous inclusions; they have a maximum length of 2 mm., and a maximum width of .7 mm.; the extinction is almost parallel, indicating oligoclase. Some orthoclase crystals were seen, as well as small crystals of quartz. Biotite was noted occurring in irregular shaped crystals, partly altered to chlorite. Epidote and magnetite are also present.

Dioryte Porphyry.—A large stock of this porphyry (13 Rossland) occurs as the country rock common to all the mines of the Rossland district. It is of a dark color with large phenocrysts of monoclinic pyroxene, biotite, amphibole, and feldspar, in a finely crystallized groundmass, which, under the microscope, proved to be hornblende, feldspar, and biotite.

In thin sections, Figs. 11 and 12, the feldspars are seen to be plagioclase; they are idiomorphic and are polysynthetically twinned, after the albite law; the crystals have a maximum length of 1.2 mm. and a width of .4 mm.; a number of readings of the extinction angles on the twinning planes varied from 21° to 28° indicating labradorite.

The monoclinic pyroxene, diopside, is idiomorphic, and contains many inclusions; alteration to serpentine, chlorite, and amphibole is seen. The crystals have a maximum length of 1.4 mm. and a width of .6 mm.

Hornblende, both primary and secondary, was observed; it is panidiomorphic with a maximum length of 1.5 mm. and a width of .6 mm.

The biotite has no distinct form, but occurs in irregular patches. Magnetite is also present and the groundmass is composed of hornblende, biotite, and feldspar.

SUMMARY AND CONCLUSION.

It will be observed from the foregoing descriptions that the rocks of the Rossland district have a certain general relationship with each other. The kersantytes, camptonytes, minettes, and vogesytes, all have a lamprophyric structure; the kersantytes and minettes are both biotite bearing, the former having plagioclase feldspar in predominance over the orthoclase, while the latter has the proportions of the two feldspars reversed. The camptonytes and vogesytes are augite and hornblende bearing rocks having these two constituents generally in excess over the feldspars; the camptonytes contain more plagioclase feldspar than orthoclase, while the vogesyte contains a greater amount of quartz and orthoclase than plagioclase. While only the typical lamprophyres have been described in this paper, the writer has found various gradations of these lamprophyres into one another.

The occurrence of these lamprophyres in America is rare; a kersantyte has been described from Minnesota.* Dikes of kersantytes, vogesytes and minettes were found in the Little Belt mountains of Montana,† and at Franklin Furnace, Sussex county, New Jersey,‡ and at Castle mountain,§ Montana, and camptontytes were found at Campton Falls, New Hampshire,‖ and in the Lake Champlain region.¶ Small dikes of campton-

*N. H. Winchell, *The Geological and Natural History Survey of Minnesota*, 1898-1900, vol. 5.

†W. H. Weed, *20th Annual Report, U. S. G. S.*, Part 3, Washington, 1898-99, pp. 538-545.

‡J. S. Diller, *Bulletin 150, U. S. G. S.*, Washington, 1898, pp. 236-238.

§W. H. Weed and L. V. Pirsons, *Bulletin 139, U. S. G. S.*, Washington, 1896, pp. 110-114.

‖J. S. Diller, *Bulletin 150, U. S. G. S.*, Washington, 1898, pp. 238-240.

¶J. F. Kemp and V. F. Marsters, *Bulletin 107, U. S. G. S.*, Washington, 1893, pp. 29-32.

yte and vogesyte occur at the 200 foot and 400 foot levels of the Dorleska mine, Union creek, Trinity county, California. The lamprophyres of this locality contain considerable calcite and are badly weathered.

These locations are the most notable occurrences of the lamprophyres in America; the rocks have the same general composition as the Rossland rocks, but are all more or less weathered and decomposed, while the Rossland rocks are very notable for their great freshness and beauty of their sections. They were nearly all taken from several hundred feet underground, under conditions where lamprophyres have seldom been collected.

Along with these are the hornblende dioryte and dioryte porphyry; in general composition these are like the camptonytes and kersantytes but lack the lamprophyric structure.

The monzonytes and syenytes are light colored, acid and granular. Their intergradation, as shown by a study of thin sections and their apparent intergradation in the field suggest the probability that they are products of differentiation from the same parent magma. It was, however, not possible to determine from the data at hand whether the dioritic rocks were differentiated before the syenytes and monzonytes, although this seems probable.

THE BRAGDON FORMATION IN NORTHWESTERN CALIFORNIA.

By Oscar H. Hershey, Berkeley, California.

(Continued from April number, page 256.)

THE STRUCTURE OF THE EASTERN BRAGDON AREA.

The Bragdon and Clear Creek formations occupy a broad, comparatively shallow, basin-shaped depression in the surface of the upturned and eroded Paleozoic rocks. This basin is lined by the volcanic series which is overlaid in the central portion by the shales, quartzytes and conglomerates. Originally the Bragdon formation completely covered the Clear Creek rocks, but it has been upturned around the borders, eroded and the volcanic series laid bare. At various places within the limits of the Bragdon area, the streams, such as Trinity river and Clear creek, have cut down through the shales into the volcanic rocks. In several former papers, already referred to in this, I have described the system of folds which traverses this area. Trinity river traverses these folds transversely and across each arch has cut down beneath the shales.

In some of these small isolated Clear Creek areas encountered deep in the valleys within the Bragdon area, vesicular lavas and tuffs are present in unmistakable form. As a locality for the latter I will mention a point on the stage road about one mile south of Bragdon and for the former almost any greenstone outcrop near Bragdon. These outcrops are identical in character with outcrops along the Sacramento river near Copley. Prospecting the contact shows that these tuffs and lavas pass under the shales all around these isolated areas. Similar altered tuffs and lavas pass under the shales nearly all around the Bragdon area. I can see no escape from the conclusion that the Bragdon formation in this eastern area is nearly everywhere floored (with an important exception to be noticed later) by the volcanic series.

The relation of the Bragdon to the Clear Creek formation is quite different from that of the Pit shales. I have never seen the least evidence of interstratification between the volcanic material and the Bragdon shales. The relation is one of nonconformity. The shales rest indiscriminately on different members of the lower series. By means of the inter-Bragdon volcanic areas one may trace a belt arrangement of the volcanic phases similar to that near the Sacramento river. For instance, the stage road between French Gulch and Trinity Center crosses, in descending the western slope of Trinity mountain, a narrow belt of altered rhyolyte which has a direction apparently easterly and is bounded by the ordinary altered andesyte. This altered rhyolyte penetrates deep into the volcanic series and is either a sheet standing on edge or a dike. It is cut off sharply by the base of the overlying shales and whether a tilted sheet or a dike, much of it must have been removed by erosion before the shales were deposited. This altered rhyolyte belt shows that rhyolyte was developed this far west and its rather uncommon occurrence in Trinity county probably is due to its having been removed by erosion previous to the deposition of the shales.

At several places in the Trinity valley I have encountered quartz porphyry dikes (containing quartz phenocrysts) rising through the greenstone and cut off abruptly and squarely by the shale contact. I will mention one on the east side of Trinity river, near the mouth of Bear gulch, about three miles south of Bragdon. There is never any indication of contact metamorphism where these dikes adjoin the shales. Nor are there any fragments of the shale in the porphyry. None of the rock types which are characteristic of the Clear Creek series ever rise into the shales. The only intrusives which are ever found in the Bragdon formation belong to systems which are known to be post-Jurassic in age. Serpentine occurs on its borders and possibly in a few cases as dikes intruded into the shales. Granite adjoins it between Lewiston and the Tower House and has produced within it a typical contact metamorphic zone.* Apophyses from this granite occur in the shales. Along the Trinity range at many places, as near Deadwood, French Gulch and east of Bragdon, there are in the shales dikes of a granite porphyry related to the granite batholiths. The foregoing are nearly all the intrusives observed in the eastern Bragdon area, but there are a few small dikes of a fine-grained dioritic rock, a system also occurring in the granite areas. One example may be seen near the Ivanhoe quartz prospect on the west side of Trinity river about three miles south of Bragdon. In general, the formation is remarkably free from intrusives of any kind, a fact which has to be explained by those who consider the greenstone under it as an intruded mass, a sill or laccolite.

The Western Bragdon Areas.

Emerging from beneath the Cretaceous rocks near Harrison Gulch in western Shasta county and trending northwestward by Hay Fork, Hawkin's Bar and Willow Creek to Hoopa valley, there is a belt of Mesozoic rocks consisting of the Clear Creek volcanic series and the Bragdon formation. It has a known length of 65 miles but probably extends far to the northwest in the lower Klamath river region. It has a width of from three to five miles. Southeastward from Hay Fork it has been sharply folded and the two formations outcrop in long narrow belts. Without a careful examination the igneous belts might

* Amer. Geol., vol. xxxi, April, 1903, p. 242.

be thought to be dikes in the slates. I have spent over six weeks at a point about six miles southeast of Hay Fork and have vigorously prospected along the contact between the volcanic material and the shales, so that I believe the following statements are not mere guesses:

The volcanic series in this region seems to be more basic than is usual in the vicinity of the Trinity and Sacramento rivers, and perhaps a large portion of it is altered basalt. There seems to be more lava and less tuff than farther east. Much of the lava is vesicular or amygdaloidal. There seems to be less alteration than is usual in the series. A representative suite of specimens from this area studied in the petrographical laboratory along with as complete a set from the Clear Creek volcanic series of the area near Redding, I should expect to result in the suggestion that they are not of the same age and do not represent the same period of vulcanism. However, I map this western area as Clear Creek because of its structural relations.

The Bragdon formation southeast of Hay Fork village differs from that of the eastern area in being finer in texture. The conglomerates farther east are here represented only by coarse sandstones, rarely becoming coarse enough to deserve to be termed fine conglomerates. They are composed of fragments of the same cherts as are the conglomerates of Trinity mountain. They occur often in heavy beds interstratified with the shales, and there is no unusual development of them at the base of the series. The shales are black and hard. They are very distinctly laminated and the bedding planes are quite evident at every outcrop. The same rate of decrease in thickness and texture of the Bragdon formation observed in the eastern area in going southwestward from its outcrop along the Sacramento river, if continued to the Hay Fork region, would produce precisely the characters which we find southeast of Hay Fork village. All the western belts I consider to have been deposited in the Bragdon body of water far from the the eastern shore and perhaps yet farther from any other shore.

The volcanic series in a tributary of Dobbin gulch, about six miles southeast of Hay Fork was seen to rest on the cherty slates of the Paleozoic series. The basal stratum of the former seemed to be a lava sheet, in the lower portion of which there were angular fragments of the cherty slates. The latter were reddened by baking for a short distance beneath the lava. At the top of the volcanic series an entirely different relation was observed. The non-cherty Bragdon shales rest on the volcanic material without the least evidence of intrusion. The contact is straight except for the folding of the rocks. Diabasic dikes rise in the volcanic material but do not penetrate into the overlying shales. The contact here just as sharply separates formations containing abundant greenstone material from a formation from which it is totally absent as in the Trinity Mountain country. Certainly the relation between the Paleozoic rocks, the volcanic series and the overlying shales is the same as that of the eastern area.

Farther north along the main western belt there is not such sharp folding but rather a simple synclinal structure, so that the Bragdon formation generally outcrops as a single rather broad belt bounded on either side by a narrow belt of the volcanic series. On approaching a Bragdon area one invariably finds it bordered, except where the dip indicates that the boundary of the shales is a fault, by a strip of igneous rock in which occur tuffs. Igneous material is very abundant in the Paleozoic rocks of the neighborhood, but I have never observed any tuff beds in the series west of the Sacramento river. There is a single horizon in that region in which occur surface volcanic materials, and whenever I encounter it, I expect to see the Bragdon formation next and am generally not disappointed.

An extended section of the Klamath region traversed by the lower Trinity and lower Klamath rivers appears to have suffered an unusual amount of dynamical metamorphism. The schistose slates of the Paleozoic formations have been converted into distinct micaceous schists. These differ from the more ancient schists of the Abrams formation in that the bedding planes are totally destroyed and the texture is finer. The Abrams formation was crystallized by thermo-metamorphism and these Paleozoic schists were altered by shearing. They are strongly developed along the trail between Hoopa valley and Weitchpec at the mouth of Trinity river as well as up the Klamath river to the mouth of Bluff creek.

The Mesozoic rocks of that region have also been sheared. The volcanic material has been altered to a rock closely resembling the amphibolite schist of the Sierra Nevada region. Schistosity has been superimposed on the bedding structure of the Bragdon formation, but without totally destroying the latter: The coarse sandstones are still macroscopically apparent as such, but the grains have been flattened as in a squeezed conglomerate. Usually the planes of schistosity and the bedding planes are practically parallel so that the formation still retains one of its great chraacteristics, that of regular and straight lamination.

A line drawn almost due north-south through a point about two miles east of Orleans on the Klamath river and a point about an equal distance east of Hawkins' Bar on the Trinity river will separate the territory in which this intense metamorphism has occurred from one on the east in which the same formations are very much less altered. No cause can yet be assigned for the limitation of the dynamical action. It seems to date from a time succeeding the Jurassic sedimentation, but antedating the early Cretaceous peridotyte intrusions, and it was probably connected with the great post-Jurassic folding of the region.

At Orleans, in Humboldt county, there is a Bragdon area traversed by the Klamath river for several miles. It trends north-south. A belt four or five miles wide properly belongs to this formation, but it is interrupted by serpentine and another igneous *massif*. Where the eastern border was observed at the Ten Eyck mine above the mouth of Salmon river, there is a narrow belt of sheared tuffs which is succeeded by the cherty limestone-bearing Paleozoic rocks. The schistose slate of the Bragdon formation preserves its thin-bedded shale and heavy-bedded coarse sandstone structure. Both types are splendidly exposed at Orleans where an Indian, Red Neck, ferries travelers across the river. The formation here has a regular westerly dip. This Orleans area continues southerly through the mountains for many miles and may connect with the main western area in the vicinity of Hoopa valley.

In traveling up the Klamath river, another Bragdon area was encountered at the mouth of Slate creek, nearly midway between Weitchpec and Orleans. It has the same lithologic characters as the others and is bordered on one side by the altered tuffs, but the other boundary is probably a fault. It is apparently no more than a fourth of a mile in width. The rocks appear to be less closely folded north of the Klamath river than farther south and in that direction the Bragdon series may be preserved over extensive areas. From the Trinity river southward there is a single western belt.

The main western Bragdon-Clear Creek belt from a point east of Hoopa valley to the Sacramento valley, is bordered on the east by a belt of rocks containing limestones which have yielded Carboniferous types of fossils at a number of localities, and is considered as probably Upper Carboniferous or perhaps even Permian in age.* There is little doubt of its being newer than the Baird shales on the McCloud river. As Mr. Diller places the Bragdon formation at the base of the Carboniferous section in the Sacramento region, if he recognizes as Bragdon the western belts which I have so identified, he will expect the series to pass easterly under the Upper Carboniferous rocks. Mr. Diller has also shown the presence of a Devonian belt west of the Bragdon belt. We have then an apparent regular easterly succession of pre-Devonian schists, Devonian strata, the Bragdon-Clear Creek series, and Upper Carboniferous rocks. Mr. Diller assumes apparently that the broad belt of Paleozoic rocks east of the fossiliferous Carboniferous belt belongs to a period at least not older than the Carboniferous and on this basis advances the suggestion that the major structure of this region is that of an easterly tilted fault block whereas my opinion is that the structure is geosynclinal. Between the Upper Carboniferous limestone belt near Hall City and the schists on the east there is an interval of ten miles; and the same interval in the latitude of Patterson's is fifteen miles. This is occupied by a great thickness of extremely cherty-shistose slates whose lithologic characters are more like those of the Devonian than the Carboniferous strata of Shasta county.

I notice some difference between this broad, very cherty belt and the Upper Carboniferous belt west of it. Chert occurs in the latter in much less abundance and the slates are harder and more evident to one traversing the area. The limestones in the known Carboniferous are heavier in development and more inclined to display bedding planes. Both belts are characterized by great quantities of intrusive rock. Taking out those intru-

* *Amer. Jour. Sci.*, vol. xx, May, 1903, pp. 348-350.

sives which are known to be post-Jurassic in age, there will remain in the very cherty belt, innumerable diabasic and dioritic dikes which are usually small. In the known Carboniferous belt, similar material occurs in much larger bodies. This may mean little, but it helps one to distinguish this belt. I believe I have crossed these Upper Carboniferous rocks near the mouth of Salmon river in line with the formation as it is developed at Patterson's, but the broad belt east of it I consider as most probably Devonian in age. The structure then will be that of a syncline. Near the center are the newest rocks, the Bragdon formation of probable Jurassic age. This is bordered by Triassic volcanic rocks. Next on the east come Upper Carboniferous rocks, and perhaps a corresponding belt may be on the west. Farther out on both sides we seem to have Devonian rocks and these followed by pre-Devonian schists.

The total absence from all of the western Bragdon areas of intruded igneous material such as everywhere abounds in the known Paleozoic areas must be significant. To place this Bragdon series in the Upper Carboniferous or any older period, one must assume that the dike material exercised a remarkable selection. My interpretation is that after the Paleozoic series was completed, the dikes were injected into it during the Triassic period and that portion of the igneous material which reached the surface became the lavas and tuffs of the Clear Creek volcanic series. Clear Creek areas occur in the supposed Devonian belt east of the known Upper Carboniferous belt and are clearly non-conformable to the Paleozoic rocks. Presently the vulcanism ceased, the volcanic land was eroded, then submerged and the Bragdon formation laid down. We have in these western areas the same stratigraphic relations as in the eastern Bragdon area.

THE AGE OF THE BRAGDON FORMATION.

In the vicinity of Delta, on the Sacramento river, the pre-Bragdon erosion of the volcanic series seems to have proceeded to the extent of cutting it through in many places and making it discontinuous. This enables the Bragdon formation to come down on to the Paleozoic rocks. Last summer, while following the Little Dog creek trail and again the trail on the line of the new wagon road between Delta and Trinity Center, I noted, with surprise, small areas of silicious shales like the Paleozoic, within the Bragdon area without any volcanic material separating the two formations. The Bragdon formation in this region comes into the extreme northwestern corner of the Redding quadrangle of the geologic map of the United States and Mr. Diller has recently studied it in this territory where it comes directly into contact with the Paleozoic rocks, an abnormal area. So far as I am aware, Mr. Diller has, otherwise, studied the formation merely on rapid reconnaissance trips which were insufficient to make him familiar with its true general structural relations with other formations.

Mr. Diller says, *"The relation of the Bragdon formation upon the eastward to the Baird, appears to be that of conformable stratification." He does not say that he found it actually under the Baird formation. Probably he found outcrops of highly inclined Bragdon adjoining outcrops of Baird shales having the same strike and dip. If he found the Bragdon shales passing under the Baird shales, I would suspect overturning or thrust faulting. In view of the almost overwhelming evidence gathered elsewhere that the Bragdon sediments were deposited on a volcanic series which unconformably rests on stratigraphically higher Carboniferous rocks than the Baird shales, I suspect that the apparent conformability of the Bragdon and Baird formations is deceptive.

So far I have only presented evidence that the Bragdon formation is newer than some Triassic rocks. Mr. F. M. Anderson probably recognized that it rests directly on Triassic volcanic rocks and assumed its age as also Triassic. One of the objects of my trip of October, 1901, into the country of Pit river and Squaw creek was to search for an equivalent of the Bragdon conglomerates in the Triassic and Jurassic section of that region. Under instructions from Mr. Diller I was able to visit typical exposures of all the formations, but I found nothing similar to the Bragdon formation.

The Pit formation is a sandy shale without prominent conglomerates and without the rapid alternation of very fine and much coarser sediments that characterizes the Bragdon. Moreover, it is interstratified with the volcanic series so that there is no interval between the two which might, elsewhere, be occupied by the Bragdon formation. Narrow remnants of a shale

* *Amer. Jour. Sci.*, vol. xv, May, 1903, p. 352.

formation occur along a north-south belt a few miles west of Redding. These shales are interstratified with the upper portion of the volcanic material and I consider them Pit in age. They are quite unlike the Bragdon formation occurring ten miles farther west. I am certain that the Bragdon formation is not the equivalent of the Pit.*

It is out of the question that the Hosselkus limestone resting conformably on the Pit shales is the equivalent of the absolutely non-limestone-bearing Bragdon series; and the conformably overlying Monotis-bearing shales are totally unlike the conglomerate-bearing Bragdon series. That closes the Triassic and we have found no place in it for the Bragdon formation.

The first Jurassic formation on Squaw creek is a great mass of shales which appeared to me to be conformable to the Triassic strata. This Bend formation is quite unlike the Bragdon series, not only in the character of the shales, but also in the absence of much conglomerate or sandstone and in the presence of coarse tuff beds and much intruded igneous material. The succeeding formation, the Morrison sandstone, contains conglomerates in rather heavy beds, but there is little resemblance between them and the Bragdon conglomerates. The former formation is softer, lighter in color, more sandy and contains no shales which might be confounded with the Bragdon shales. Moreover, it is well supplied with intruded igneous material such as never is seen in the Bragdon areas. All the Devonian, Carboniferous, Triassic and Jurassic rocks up to the top of the Morrison formation, wherever they are developed in northwestern California, are abundantly supplied with dikes greenish rocks and the Bragdon is the only known pre-Cretaceous formation in which they do not occur. Evidently the vulcanism continued until after the deposition of the Morrison sandstone, but ceased before the Bragdon sediments began to accumulate. Surely some significance must attach to this.

The Bragdon formation is older than the Horsetown and Chico. It was folded, intruded by granite, deeply eroded and the Horsetown deposited unconformably on it and on the granite. It is quite unlike the Knoxville shales. It is older than

* It may be objected to my method of reasoning that any formation can be expected to change character in distance, but the distances here involved are too short.

the Franciscan series. Typical Franciscan rocks occur in the valley of Mad river in Humboldt county where they rest unconformably on the pre-Devonian schists of the South Fork Mountain belt. They contain conglomerates in which are pebbles which seem to have been derived from porphyry dikes of a system occurring in the neighboring Klamath region and there are black grains in abundance which seem to me referable for an origin to the silicified Bragdon slates occurring on the opposite side of South Fork mountain. The Bragdon formation was involved by the orogenic activity of the Appalachian type which acted on the California rocks at the close of the Jurassic period and its pre-Cretaceous age is beyond dispute.

It is now cornered into the last epoch of the Jurassic period.

In the Sierra Nevada region there is a formation which is remarkably like the Bragdon formation. It is the Mariposa formation which is placed in the Jurassic period but later than the Morrison sandstone. The Mariposa which I have studied along the Mother Lode belt, more closely resembles the Bragdon in the western areas than in the eastern. It appears that what is preserved of the Mariposa formation is the deep-water and not the litoral portion. Mariposa areas are bordered usually by amphibolite schist and less altered surface volcanic rocks very similar to the Clear Creek series. The Weitchpec schists resemble the most highly metamorphosed Calaveras schists, and the schistose slates of the Bragdon areas crossed by the Klamath river resemble the moderately altered Mariposa schists.

In the foot-hills of the central and southern Sierras, the sedimentary series are distributed in long narrow belts as in the western Klamath region. In the northern Sierras they are distributed in broader and more irregular belts as in the central and eastern Klamath region. A line drawn from the mouth of the Klamath river southeastward through Weaverville and Red Bluff and thence prolonged into the Sierra Nevada region will roughly separate the territory in which the pre-Cretaceous rocks are in long narrow, northwest-southeast belts from that in which they are differently distributed. This line will be oblique to the strike of the rocks.

It is true that no Mariposa fossils have been found in the Bragdon rocks, but that is no difficulty in referring them to the same or about the same age. Broad areas of the Paleozoic rocks of the same region are without recognizable fossils. It is significant, however, that plant remains do occur in the Bragdon formation and that plant remains characterize the Mariposa.

In short, as the meager paleobotanical evidence is without weight and besides does not negative a reference of its contained strata to the Mariposa epoch, and as the structural relations of the Bragdon series unmistakably point to the late Jurassic and also as the Bragdon and Mariposa formations are remarkably alike lithologically, yet decidedly different from any other formation in California, I consider it natural and scientific to refer them both to the same period of time. Of course, I recognize that a confident conclusion as to the age of the Bragdon will depend on the finding in it of better fossils; but it is not necessary to stand by with folded hands and wait for their discovery.

THE LATE JURASSIC REVOLUTION.

In some publication of the Geological Society of America, a Bulletin I think, some geologist has suggested that the Calaveras sediments were laid down in a sea extending farther east than the present Sierra Nevada region and that then there was a physical revolution which raised the sea bottom on the east and shifted the shore-line westward so that during the Mariposa epoch it traversed what is now the middle western slope of the Sierra Nevada range. I am writing this paper in the mountains where there are no libraries and so cannot give the reference, and have even forgotten the name of the person making the suggestion. But it made a strong impression on me because in line with a conclusion I had come to with reference to the Bragdon formation. In April, 1901, I suggested* that sedimentation ceased in the region west of the Sacramento river at the close of the Paleozoic era, but continued in the region east of that stream through Triassic and Jurassic time up till near the close of the latter, but was then resumed west of the Sacramento river. I will amplify this idea.

Throughout the Klamath region sedimentation ceased at the close of the Carboniferous (or the Permian) period. After a period of erosion, vulcanism began and the Clear Creek

* AMER. GEOL., vol xxvii, April, 1901, p. 238.

volcanic series was spread over the land. By depression, in the Triassic period, the sea began to invade the land from the eastward or (preferably) northeastward and the Pit shales began to form in the country now eastward of the Sacramento river. Sedimentation continued in that territory to late in the Jurassic period. How far westward of the Sacramento river these formations may have extended it is impossible to determine, but it is not likely that they were developed far in that direction or some remnants would be found in Trinity and Siskiyou counties between the volcanic series and the Bragdon slates.

During part of the time at least in which the Triassic and Jurassic sedimentation was in progress in the Pit River region the volcanic series in the country west of the Sacramento river was being leveled off by ordinary subaerial erosion, reducing it to a comparatively plane area.

Then ensued a remarkable physical disturbance. Probably it began at the close of deposition of the Bend formation and may have given rise to the coarser sediments of the Morrison sandstone and conglomerate. But the effect was not pronounced until the close of the Morrison epoch. Then a large part of the sea-bottom was raised and nearly all of the territory now included in the Klamath region east of the Sacramento river and in the northern and higher Sierra Nevadas became land. The movement was one of westward tilting and what had formerly been land now was depressed and submerged and in the body of water thus formed the Mariposa-Bragdon strata were laid down.

The eastern shore-line, I feel some confidence, was not many miles east of the present site of Delta and probably thence trended in a southeasterly direction. The Mariposa that I observed along the Mother Lode belt I should say was deposited from 10 to 20 miles distant from the shore-line, judging by the position of Bragdon strata of corresponding texture. There are some features about the Bragdon formation which indicate that it was not deposited in the open sea, but in a broad inland water-basin, perhaps in part brackish. It is in that manner that I account for the absence of marine animal remains. The Mariposa portion may have been more favorably situated for the life of marine animals and thus it derived its spare fossils of that class.

The western shore has not been discovered. In the most western Bragdon areas there are no traces of an approach to it. It may have been a narrow and discontinuous strip of land on the edge of the continental plateau.

One of the most interesting features of this late Jurassic revolution is that it inaugurated deposition in California territory under radically different conditions from those that formerly obtained. The Triassic, early and middle Jurassic strata seem to have been deposited on the northeast side of a broad land area which occupied the site of the present Coast ranges, the western part of the Klamath region and most of the Sacramento valley region. After the revolution the site of this old land area was a territory subject to repeated submergences from the beginning of the Mariposa-Bragdon epoch to very recent times. During its second great depression, the Franciscan sediments were laid down, but between the Mariposa-Bragdon and the Franciscan epochs there seems to have been a long erosion interval.

Las Perlas Mine, Dorleska, Calif., June 23, 1903.

NOTE ON SOME CONCRETIONS IN THE CHEMUNG OF SOUTHERN NEW YORK.*

By E. M. Kindle, New Haven, Conn.

During the progress of the survey of the Watkins Glen quadrangle, a bed of concretions which presents some unique features came under the writer's observation. This bed occurs in the Chemung sandstone, and is exposed in a quarry at Rossburg a few miles southwest of Elmira, N. Y. The character of the beds associated with the concretions is shown by the section of the beds associated with the cocretions is shown by the section of the quarry which follows:—

8.	Thin-bedded sandstone and shale	10 ft.
7.	Sandstone with numerous concretions	2 ft.
6.	Drab colored shale	1 ft.
5.	Sandstone	0′ to 1 ft.
4.	Gray shale	6 ft.
3.	Heavy bedded gray sandstone, of even texture, changing in the north part of the quarry to a bed of concretions of large size	5′ to 6 ft.

* Published by permission of the Director of the U. S. Geological Survey.

2. Thin bedded gray sandstone, . . 18 in.
1. Heavy bedded sandstone . . . . . 4 ft.

It will be noted that two zones of concretions appear in the section about eight feet apart. Those in the upper horizon are small, concretionary masses similar to those commonly met with in the Chemung, and present no features of special interest. The concretionary aggregations of the lower bed, (No. 3), are for the most part much larger than those of the upper. The long quarry face extending for more than three hundred feet along the side of the hill affords an excellent opportunity to examine this bed. At one end of the quarry it is seen to be a fine grained, massive sandstone, entirely free from concretions. This sandstone bed breaks up towards the middle of the quarry into a mass of arenaceous concretions of various sizes. These vary from less than a foot in diameter to masses five or six feet across and weighing many tons, the larger sizes predominating. The shape is extremely variable and includes a great variety of irregular forms, a common type among the larger masses being roughly quadrilateral in cross-section, as shown in figure 1.

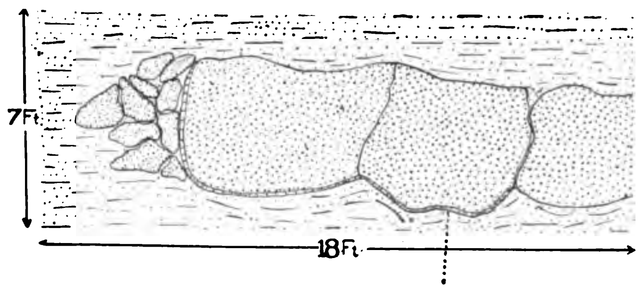

Fig. 1. Concretions in sandstone with a band of fossils forming part of the outer shell of the larger ones.

These aggregations are much harder than the associated beds, and contain apparently a larger percentage of ferruginous matter, and have a darker color than the rest of the sandstone bed to which they belong. In brief, they agree in most of their general features with the characters of arenaceous concretions which have been observed in scores of other concretionary bands in the Chemung, save in one particular.

The unusual feature to which attention is invited is the remarkable position which a band of fossils 4-6 inches thick assumes with reference to the concretions. Fossils are not generally distributed through the concretionary bed, and appear to be almost entirely absent except in a thin seam, 4-6 inches thick, belonging near the bottom of the concretionary zone. This band is composed almost entirely of common Chemung fossils; but instead of following the horizontal direction of the underlying strata it has in many places a sinuous course, corresponding to the base and sides of the larger concretionary masses. Where this band is present it separates the lower sides of the concretions sharply from the inferior beds, bearing much the same relationship to them that the outer shell of a nut bears to the inner. Not only does this fossil band follow the irregular basal outline of the concretions, but frequently it bends abruptly upward, and, taking a vertical direction, follows the side of a concretionary mass as shown in the figures.

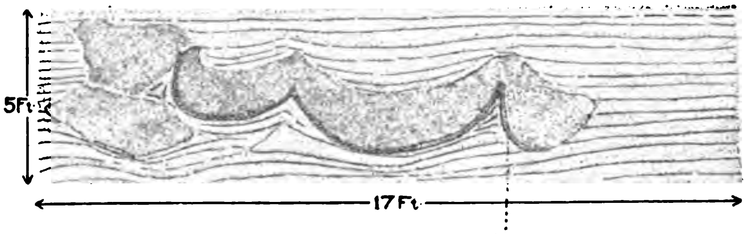

FIG. 2. Showing sharp upward flexures of the fossiliferous band at the base of the concretions.

It has been observed in at least one instance, as shown in fig. 3, after having followed around the base and side of a concretion, to be reflexed at the top and follow for a few inches the horizontal upper outline of the mass.

It seems apparent from the remarkable relationship of the band of fossils and the concretions, that the commonly accepted theory of chemical segregation is not alone a satisfactory explanation of the phenomena involved. The abnormal position of the zone of fossils filling the role of outer shell to a concretionary mass seems to require the action of some physical agency for its explanation. The agency which disturbed the original horizontal position of this band must have acted

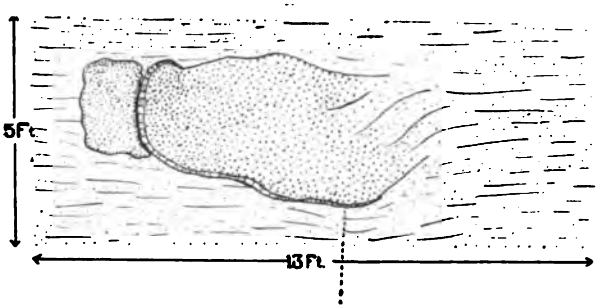

FIG. 3. Showing reflexed fossiliferous zone.

on the sediments before their complete consolidation, since there is no evidence of fracture or crushing in the beds nor of distortion in the fossils. If it be conceded that the reflexed condition of the fossil band was brought about soon after the deposition of the associated sediments, while they were in a semi-plastic condition, the development and expansion of gases beneath an impervious zone would account for the disturbed condition of the zone of fossils. The tendency of a gas accumulating beneath impervious beds would be to lift them upwards along lines of least resistance into approximately vertical positions, such as we find the fossil band to have assumed. It appears not improbable that the gases supposed to have disturbed the normal position of the strata associated with the concretions may have been a factor in inciting the chemical segregation which has developed a composition unlike that of the associated beds in this and other bands of concretions.

The behavior of gases in recent mud in a manner somewhat scimilar to that which is here assumed has been observed by Aggasiz and Hosford. The latter states that they observed the "production of raised hemispherical surfaces in the mud near Cambridge by the rising of gases from decomposing organic bodies."*

* *Am. Assoc. Adv. Sci.*, vol. iv, p. 12.

NOMENCLATURE OF THE GOLD-BEARING METAMORPHIC SERIES OF NOVA SCOTIA.*

By J. EDMUND WOODMAN, Halifax, N. S.

CONTENTS.

Location and extent.—The rocks frequently given the above name occupy most of the southern part of the peninsula of Nova Scotia. They are largely composed, as stated many times in papers from 1828 to the present, of alternating slates and quartzytes, with many bodies of intrusives, chiefly acid and abyssal. Their present distribution is in the form of a wedge, wide in the west and narrowing steadily eastward. The area of this wedge has been variously estimated at from 6000 to 8500 square miles, including islands off the coast but without deducting lakes. A fair estimate is about 8000. As fully 3500 square miles are occupied by intrusives, only 4500 remain as the surface area of the stratified rocks.

We lack full knowledge of the area of stratified material in those parts of the territory mapped heretofore in general as intrusive, but it cannot be great. In the east, the granites south of Chedabucto bay contain patches aggregating at most a few square miles; and in the west, small areas of gold-bearing rocks have been noted in the vicinity of New Ross, in the middle of the great western massif. The total amount of all the included sediments cannot, however, add much to the area of the series.

The length of the series is that of the whole mainland portion of the province; for it extends from cape Canso and Park ledge on the east to Bear cove and cape St. Mary on the west, a distance of approximately 280 miles, chiefly on the strike of the strata. Its width at the eastern end, including the granites, is eight miles. Its greatest width across the strike is along a line southeast from the head of St. Mary's bay, in the western half, and measures approximately 75 miles.

* The first of a series of papers extracted and altered from part of a thesis accepted at Harvard University for the Doctorate of Science in 1902, entitled "Geology of the Moose River district, Halifax county, Nova Scotia; together with the pre-Carboniferous history of the Meguma series."

Boundaries.—On its eastern end the series is bounded by water. It is noticeable and important that the prolongation of its strike would carry it south of the old rocks of southern Cape Breton. On the west water is also adjacent. On the south the series is bounded by the ocean, except in two localities. These are at the head of Mahone bay and of St. Margaret's bay, west of Halifax, where two small patches of Carboniferous rocks lie upon the upturned and eroded edges of the older strata. The unconformity is evident, although the actual contacts are not visible.

On the north the series is in unconformable contact with younger rocks throughout the distance from the mouth of Salmon river on the east to the last exposures of the Siluro-Devonian, near South Range in the town of Weymouth, on the west. From Salmon river east to the end of the mainland, Chedabucto bay bounds the series. West from the mouth of the river to latitude 61° 40′, a distance of approximately 15′, Devonian is adjacent. Here the Carboniferous replaces it, lying upon both the lower Devonian and the gold-bearing series; and continues westward to the vicinity of Kentville, whence Triassic and Siluro-Devonian alternate as the bounding formation to the head of St. Mary's bay. From this point westward, water lies to the north.

The series as a unit.—From the highest beds recognized in the series to the lowest now exposed, the gold-bearing rocks appear to be conformable, and to constitute one great structural unit. There have not been reported even those local unconformities shown in the large cases of cross bedding in many series. The first reference to these strata in geological literature was by Jackson and Alger ('28-'29). The authors reported no more than that there were clay slates and "quartz rock" in a region embracing but a small part of that really covered by the beds. By '36, however, Gesner had recognized the existence of a definite series extending over a wide territory, although he did not separate it from the fossiliferous Devonian in the northwest of the province. The northern boundary on the map accompanying his paper is very generalized and incorrect, but is the first attempt to delimit the old metamorphic strata. In '43 Gesner assigned the rocks of the peninsula to definite geological horizons, and called the southern or unfossiliferous part of his lowest series Cambrian (p. 187). This is the gold-bearing series. The chief work in separating it from the various later ages, especially Silurian and Devonian, was accomplished by Sir William Dawson ('55, '68), in the first two editions of "Acadian Geology." Yet even he did not recognize the complete unity of the series; and, indeed, this has never been sufficiently emphasized.

Chief structural features.—The most pronounced structural characteristic of these thoroughly altered rocks is the presence throughout their extent and thickness of parallel anticlines and synclines, striking northeast or east. They were noted by Gesner in '43. But the feature which has made economic exploitation possible is the location on the anticlines of many small structural domes of various degrees of development, giving under denudation a curved and often elliptical strike to the strata. They seem not to have been noticed until after the discovery of gold in 1860 had excited observation on the structure of the economic areas. The first detailed work to bring out the presence of such domes as a type structure was done at Waverley by H. Y. Hind, and published in '69. The only survey embracing a wide area in sufficient detail to print on sheet maps has been that of Mr. E. R. Faribault, of the Geological Survey of Canada. These excellent studies, covering all of the series from the eastern end at least as far west as the Nova Scotia Central railway, and published as far west as the longitude of Halifax, deserve to be much more widely known; for their structural accuracy is considerable, and has been achieved in the face of difficulties of no small importance. In many cases, domes opened by mining operations have been especially mapped by him, on a very large scale. The work of professor L. W. Bailey, summarized in his report of '98, gives the only account of the geology of the western quarter of the province, but does not confine itself to the gold-bearing series.

In '63 Campbell recognized the two-fold nature of these rocks, chiefly arenaceous in a lower division and argillaceous in an upper one. This discrimination was based upon study in the eastern part of the province, and is still valid for that section. In the west, however, Bailey has added a division between these two ('98).

Names previously applied to series and subdivisions.—The series has been known as a unit for sixty-eight years; its two great divisions have been recognized for more than forty years; and yet, in the many geological references to the country, including detailed as well as general papers, neither the series nor its subdivisions have until recently received even tentative definite names. Jackson and Alger ('28-'29) included such of the territory as was then known in their "transition clay slate." Gesner ('36) called it "primary district," because granite apparently predominated, and included the "transition clay slate" in this. Dawson ('50) wrote of it as the "granitic group"; in '55 changed this to "granitic metamorphic series," and later ('68) to "Atlantic coast metamorphic series." Finally Ami (:00) remarks that these rocks "have been designated as the '*Atlantic Coast* series' or *Acadian* 'group' or 'division.'" Other names have been applied from time to time, all alike in being descriptive. In the same tenor have been most of the names given to the subdivisions. In '63 Campbell called the lower the "quartzite group," and the upper the "lower clay slate group." In '87 Faribault referred to the former as the "ferruginous slate group." In '98 Bailey made for the western end of the province three formations, the lowest the "quartzite division," the middle the "banded argillite division," the highest the "black slate division." In :00 Ami wrote "To the 'quartzite group'...the designation *Guysborough* formation appears appropriate, whilst the term *Halifax* formation is proposed for the 'slate group' of the gold-bearing series" (p. 195). I believe these have not, however, been employed in any later references to the series, by any author.

The descriptive names used before the publication of Dr. Ami's paper are all appropriate as such; but it is better geological usage to give series and subdivisions distinct names inapplicable to other strata. Dr. Ami recognized this, in the article above quoted; and the following, which also explains the status of the names used by him, illustrates the point. "In dealing with the classification of the various formations in Canada...the writer has been compelled to affix provisional formational names to various series of sedimentary rocks which have not as yet received any designation. He deems it, however, a case of dire necessity in this case, inasmuch as it is impossible to classify geological horizons or subdivisions in the strata of the earth's crust, as developed in Canada, according to the latest and most approved methods and in keeping with the classification of other geological formations in the same systems in other parts of the world, without formational names. There are horizons and formations in Canada which are known only in terms descriptive of their lithological or palæontological characters, combined in some cases with their economic relations, and these are not as a rule acceptable as geological terms of value in nomenclature" (p. 188).

Proposed nomenclature.—Having met with the same difficulty of ambiguity and indefiniteness for some years in working upon the gold-bearing series, I have ventured to propose definite names for the three units—the series, and its two formations. It was thought best to seek for Indian names, as not liable to duplication, rather than to use geographical terms taken from the province. It is difficult to find appropriate names from the latter, not already in use or likely to be given in the future to newly discovered horizons elsewhere on the continent. But after long consideration with the two other chief workers in the field, Dr. Bailey and Mr. Faribault, it has been found necessary to employ both classes of names; and those offered here are brought forward with their approval.

It is here proposed to give to the gold-bearing metamorphic series of Nova Scotia the name "Meguma series"; to the upper or slate member, the name "Halifax formation"; and to the lower or quartzyte member, the name "Goldenville formation." The terms in Dr. Ami's paper were used tentatively there, and have not been employed in any more recent references to the rocks. The name *Guysborough* seems not quite suitable, because it is not the name of a definite place which is especially typical of the lower formation. On the other hand, *Goldenville* is the name of a gold district on a dome of especially well-defined and thoroughly typical structure, and has been studied perhaps more closely than any other in the series. The name *Halifax* is not all that might be wished, referring as it does to a county as well as a city. But the latter is the locality in which the upper formation attains a thickness about twice as great as anywhere to the east, and is comparatively uninfluenced by the proximity of the great western granite massif, which may have caused in part the greater alteration of less typical slates of the western half of the province. Hence it seems best to retain Dr. Ami's term for this. *Meguma* is a Micmac word, root of the native term for their own tribe; hence appropriate for rocks occupying so large a part of Nova Scotia.

Since the last discussion of terms with Mr. Faribault, he has signified his adoption of them by employing them in a modified form in a paper on deep mining, printed in a special mining number of a weekly journal called the *Nova Scotian*, published at Halifax. He there speaks of the lower group as the "Goldenville quartzite group," and of the upper as the "Halifax slate group." While useful in calling the attention of local mining men to a new nomenclature, and acting thus as a transition phrase, standing between an old order and a new, the descriptive parts of the terms appear to be unnecessary if the locality names are retained, and not in accord with the best usage; hence I would still propose the nomenclature advocated above.

No name has been given to the intermediate group of Bailey, as in the eastern part of the province it certainly is not separate member; and I have not yet been able to trace it directly into the more metamorphosed strata of the west so closely as to feel sure that it should be given a separate designation there.

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BOULDERS DUE TO ROCK DECAY.

By WARREN UPHAM, St. Paul, Minn.

Last summer, visiting Butte, Montana, in my return from a trip to the Puget Sound region, I was greatly interested in the wonderful abundance of boulders which have resulted from the decay of the Butte granite upon large parts of its extensive area. Derivation of many boulders in the glacial drift from similar preglacial surfaces strewn with loose rock masses, ready to be carried away by the ice-sheet, has therefore appeared to me highly probable, and indeed demonstrable, which, though before partially recognized, has never, as I think, been accorded its proper degree of importance.

This granite intrusion, as described by Walter H. Weed in the Butte Special Folio, No. 38 of the U. S. Geological

Survey, published in 1897, has a width of 40 miles with a length of 70 miles from north to south, and has been sculptured by subaerial erosion into mountains and valleys. "The granite," writes Weed, "is traversed by varying, well-defined systems of joint planes, is extensively decomposed in some localities, and weathers into rugged crags and monoliths and great boulder masses which form the picturesque scenery so frequently typical of granite areas."

From its relations to the contiguous stratified rocks, the Butte granite is shown to be not older than the Carboniferous period, and even to be possibly younger than the Laramie, after which, in the early part of the Tertiary era, the general mountain folding of the sedimentary formations of the region is known to have occurred. Since the time of intrusion of the granite, which is considered, in view of its prevailing coarseness and evenness of granular texture, to have cooled under a cover of older rocks, that cover and much of the granite itself have been eroded.

About a mile north of Butte, at the highest part of the hill tract on whose southern slope the mines are situated and the city is built, the granite bears many boulders of all sizes up to 15 feet in diameter. This hill top, strown and crowned with its weathered boulders, is 6,500 feet above the sea, as shown by the Butte Folio maps, being nearly 200 feet above the top of the rather sharply conical hill called Big Butte (or oftener simply "the Butte"), close west of the city, which thence received its name, and nearly 1,100 feet above the Silver Bow creek on the south. Specimens broken from these boulders are entirely undecayed at the depth of only a few inches, often no more than two or three inches, from their surface. The effect of weathering extends no deeper than is usually observable in granite boulders of glacial transportation and deposition, which were probably, as I now conclude, gathered in large numbers or even mostly from preglacial weathered tracts of this kind.

On the mountain range running from north to south a few miles east of Butte, the amazing profusion of the boulders formed in the progress of decay of the granite is conspicuously seen from the Great Northern railway by the traveler going northeastward, and from the Northern Pacific railway running to the southeast. As the latter gradually climbs the west side of the range to its crest and low pass at Homestake station, about ten miles distant from Butte, we everywhere saw countless boulders, variously angular and in part rounded, from a few feet in diameter up to 20 or occasionally 30 feet, spread generally almost as plentiful as they can lie on the mountain slope. Descending from Homestake eastward to the Jefferson river, the same decomposing granite, with many boulders, continues ten miles or more, to the base of the range.

The localities thus described, in the vicinity of Butte, probably equalling or surpassing any others in the world by their development of boulders in the processes of weathering and erosion, are a hundred miles southwest of the limit of the glacial drift on the upper Missouri river, as mapped by Chamberlin and Salisbury. The topographic features of the country surrounding Butte are doubtless nearly the same now as just before the Ice age; and we may well believe that multitudes of weathering boulders were conspicuous there during the long Tertiary era of deep erosion of all that region, and especially in the closing part of the Pliocene period, immediately preceding the Ice age, perhaps about 100,000 years ago.

If at that time such areas of plentiful boulders, formed by rock decay and denudation, lay within the limits of the ensuing continental glaciation, they would have yielded a great proportion of the rock masses in the drift for many miles onward in the course of the ice currents. Hence the larger share of boulders supplied to the drift from some rock areas than from others seems to me partly or chiefly due to differences in their capacity for preglacial origination of boulders ready for transportation in the ice-sheet.

The diverse conditions of the rock formations in this respect, however, were dependent in a high degree on the diverse joint structure of the rocks, favoring or hindering their separation into residual masses while being subaerially sculptured and worn away. Likewise, when glacial erosion had removed all the preglacial boulders and decaying surface of the bed rock, its jointing determined whether it should supply many or few additional boulder masses plucked away in the grasp of the overriding ice.

Abundant supplies of drift boulders from a relatively small exposed tract of the bed rock, resulting mainly, as we may suppose, from preglacial weathering and favorable joint structure, are illustrated in the farthest known transportation of rock fragments in the drift of North America, from James bay southwest to North Dakota and Minnesota, as recorded in part by Dr. Robert Bell, of the Canadian Geological Survey, whose observations are supplemented by my own. The rock thus recognized is a "dark grey, granular, siliceous felsite or greywacke....characterized by round spots, from the size of a pea to that of a cricket ball or larger, of a lighter color than the rest of the rock, which weather out into pits of the same form." It occurs *in situ,* as reported by Dr. Bell, on Long island, off Cape Jones, on the east coast of Hudson bay, where it is narrowed to form James bay, having there a southwestward strike, and probably continuing under the sea for some distance in that direction. He notes that the abundance of pebbles and boulders of this rock is the most remarkable feature of the drift on the west coast of James bay and along the Attawapishkat, Albany, and Kenogami rivers, and that its fragments have been found by him as far west as Lonely lake, and southward to lake Superior.*

Farther to the southwest and south, I have observed fragments of it, usually only a few inches, but in some instances a foot or more in diameter, occurring very rarely in the drift in the northeastern part of North Dakota, where the largest piece ever found by me was about thirty miles south of the international boundary and fifty miles west of the Red river, and at numerous localities in Minnesota, where it extends at least as far south as Steele county, seventy-five miles south of St. Paul, and a thousand miles southwest of its outcrop north of James bay.†

Another illustration of very extraordinary boulder supplies, doubtless explainable as here indicated, is seen on a tract of a few square miles close eastward of the Fabyan House in the White mountains of New Hampshire, where granite boulders, including many of great size, derived from the contig-

* *Geol. and Nat. Hist Survey of Canada.* Annual Report, new series, vol. ii, for 1886, p. 36G; compare Report of Progress for 1878-79, pp 22, 23C.

† *Geol. and Nat. Hist. Survey of Minnesota,* Twenty-second Annual Report, for 1893, pp. 33-34.

uous Mt. Deception, strow the land in marvelous profusion.*

Boulders of wasting rock formations are most plentiful on the slopes and tops of mountains and hills. Where such areas were enveloped by the ice-sheet during any prolonged stage of glaciation, the loose rock masses were swept off into the drift for a long distance on the lee side. That Mt. Washington, the culminating peak of the White mountains, still bears exceedingly abundant frost-riven masses of its underlying schist and gneiss, although it has also very rare and comparatively small glacially transported boulders found by Prof. C. H. Hitchcock near to the summit, implies that this high mountain top was enveloped only a short time by the ice-sheet when it attained its greatest thickness. Excepting the rare glacial boulders, this peak resembles, in its great numbers of residual rock fragments, the upper parts of Mt. Katahdin in Maine and of the Three Buttes or Sweet Grass hills in northern Montana, which rose as nunataks above the ice-sheet at its time of maximum accumulation.†

Besides the many residual boulders provided in preglacial times on areas of crystalline rocks for incorporation with the glacial drift, the ice-sheet also gathered many masses and fragments of the sedimentary rocks wherever it overspread their weathering cliffs along the river courses, or their turreted and pinnacled remnants of prolonged erosion, such as are common in various parts of the Driftless Area of Wisconsin, and on hilly tracts south of the glacial boundary. One of the most remarkable deposits of small and large blocks of rock, up to 25 feet in dimension, thus removed by ice currents only a very short distance from their original positions, is seen in the upper half of the left bluff of the Mississippi river in St. Paul, Minnesota, along an extent of about 1,000 feet at the northern end of the Smith Avenue bridge (commonly called the High bridge). The blocks are from the adjacent Trenton limestone, which forms a wide terrace on that side of the river and about 100 feet above it, extending for the distance of six miles from Fort Snelling to the center of the city.

Without attempting any very close estimate or computation, I am led to think, from the foregoing and other related

* AMER. GEOL., vol. xxxiii, pp. 13, 14, Jan,' 1904.

† "Glaciation of Mountains in New England and New York," *Appalachia*, vol. v, 1889, pp. 291-312.

observations, that about half of the large boulders in the glacial drift of the northern United States may be reasonably attributed to derivation from preglacial residual rock masses, already weathered into boulders, or precariously sculptured into tower-like and craggy forms, in either case very easy to be borne away in the drift. Yet this prolific source of glacial boulders has no attention (or at least no emphasis) bestowed on it in the most elaborate treatise on geology, by Dana and Sir Archibald Geikie, nor in the most valuable general works on the Ice age, by professor G. F. Wright and professor James Geikie.

In closing this short paper, I wish to add that a very fruitful study could be given to the relationship of the preglacial boulders with the exceptional profusion of boulders always observed in the marginal moraines of the continental drift areas, as compared with their less numbers on the smoother adjoining tracts of the ordinary till. The conditions of englacial carriage of boulders, giving their great predominance in the moraines, has long seemed to me of high interest, and not fully understood. Probably many of the boulders early gathered into the basal part of the ice-sheet from the preglacial weathered rocks were carried hundreds of feet above the land and during thousands of years, to be finally stranded, when the ice was melted away, in the knolly and hilly marginal drift accumulations which were formed wherever the ice border paused or temporarily readvanced during its general recession, under secular climatic changes, remaining for some geologically short time nearly stationary at each of the morainic belts.

THE CLINOPLAINS OF THE RIO GRANDE.

By C. L. Herrick, Socorro, New Mexico.

The footing of the mountain ranges facing the Rio Grande flood plain presents points of some interest. The valley deposits near Albuquerque have been described by the writer* and attention has been called to the probability of a dam across the Rio Grande valley at some point south of Albuquerque, serving to give rise, temporarily at least, to lacustrine conditions and to the deposition of the superficial marl called, in the papers referred to, "Albuquerque marl." There is reason to think that the basaltic dam at San Acacia is the remnant of the blockade referred to. At any rate, the conditions above San Acacia are distinctly different from those below that point, and the marl has not been noted below the obstruction, while it occurs at the appropriate level to the northward on both sides of the river.

South of the barrier the facies changes. The immediate flood plain has a variable width (perhaps a mile on the average) and, so far as explored, consists of alternate bands of fine loam and gravel ("Rio Grande Gravels" of the earlier papers) the latter being more abundant near the edges of the flood plain and probably composed of materials derived from deltas of lateral arroyos in an earlier stage.

This intercalation of gravels also occurs in the flood plain deposits and is of great economic importance, for it permits the introduction of slotted intake-pipes into the water-bearing levels for pumping purposes. Each such gravel bed can be converted into a subterranean basin or reservoir by the simple process of exhausting the silt mixed with it, so that a short period of pumping produces good water.

In the valley south of the barrier the slope is about four feet to the mile and water in inexhaustable amounts lies within six to fifteen feet of the surface. The complete pumping irrigation of this marvelously fertile land has been delayed by the lack of knowledge and the numerous small holdings, largely by native people, which prevent the accumulation of a sufficiently large

* Geology of the Environs of Albuquerque, Amer. Geologist, July, 1898. The Geology of the Albuquerque sheet, *Bulletin of Hadley Laboratory*, vol. ii, 1900.

block of land to warrant an adequate installation. It is now only a matter of time when this difficulty will be overcome and the vast area, capable of raising all temperate fruits and products (except potatoes), will become a vast garden.

The writer, together with his brother, W. H. Herrick, were charged wih the exploration of a part of this area and found the subterranean water universal and subject to astonishingly little variation of level during the entire season. Gravel beds are frequent and little expense is required to install a 500,000 gallon plant.

On either side of the flood plain, the irregular tongues of the inclined plains projecting from the mountains form low bluffs, interrupted by the deltas of lateral arroyos at frequent intervals. These plains illustrate processes of erosion which seem largely to have escaped the careful study they deserve. They have been described as peneplains by some geologists who have neglected the distinctions made by professor Davis in describing these structures. The writer is inclined so far to agree with Tarr* as to consider the peneplain a questionable term as applied to the western structures known to him.

These river clinoplains seem hardly to come under the head of base-leveling though the final result would be a base-level. We have, first of all, the flood plain as a plane of reference (though this is not a constant and its variations have had an important effect in the development of the lateral plains). The flood plain, of course, lies practically at right angles to the clinoplains and its inclination is so slight as to afford a reference level also.

The materials of these plains are not necessarily uniform, they consist superficially of the detritus from the adjacent mountains. In the immediate vicinity of Socorro, for instance, they contain fragments of rhyolyte, trachyte, pitchstone, andesyte, scoria, basalt, granite, dioryte, hornblendic schist, Carboniferous limestone and quartzyte, flint, etc., all derivable from the Socorro and Limitar ranges.

Near the flood plain the action of the river in earlier higher stages is easily observed. Sand-bar formation, secondary erosion, and the like, are common. Near the mountains, on the other hand, the remnants of the Tertiary formations are found

* AMER. GEOL., vol. xxi, 6.

covered by the detrital material of the clinoplain. In some cases, where erosion has cut through both, it appears that the Tertiary deposits (usually tilted and intersected by ancient basalt dikes and sheets) have been planed to a level covered by a definite limiting deposit, as by lake action, while in others, the deposit from the mountains are mingled with those of the degraded Tertiary strata. In still other cases, benches of Tertiary with the upper surface leveled protrude above the clinoplains.

The effect of the fluctuations of river level are obvious in the bluff-like projections of the clinoplains, on the bottoms, for they doubtless at one time debouched directly upon the flood plain as do the modern deltas.

Variation in the amount of lateral drainage is also represented by two sets of benches along some of the main lateral arroyos or canons. In Nogales arroyo, for example, leading from the main canon north of Socorro mountain and conveying the drainage of a vast area extending to the Magdalena range, the stream must have been much larger formerly. A bench some thirty or forty feet above the present level and forty to sixty feet lower than the top of the clinoploin is very evident, the slope of the bench being less than that of the clinoplain. In this arroyo the Tertiary deposits are exposed by erosion so as easily to be seen near the mountain. Their materials are sand and gravel and marly beds and they are disturbed by dikes and sheets of much altered vesicular basalt.

Two types of clinoplain are to be distinguished. First, the talus plain proper. This is a true talus, standing at a rather high angle which varies with the nature of the rocks and the hight of the range. At the Limitars, for example, the entire eastern exposure of which is of granite and allied rocks, the talus plain consists largely of rounded granite boulders and coarse sand of disintegration. The slope is cut by rather deep, but not precipitous arroyos and the intervals between these gullies is crowned or arched into long radiating ridges. The general surface section is, however, remarkably rectilinear.

In some places the talus plain reaches the bottoms, but generally it passes abruptly into the plain of the second type, or clinoplain proper. This is very slightly inclined with perfectly rectilinear surface section, i.e., it is a perfect plane.

This plane surface is broken by arroyos and base-leveling from the present flood plain level, but otherwise the network of erosive channels is very intricate though shallow. A very good ilustration is here afforded of degradation of soft and homogeneous materials exactly as required by the theory of peneplanation. The law is simply this: "*Whenever the angle of slope of the ridges between the radial channels becomes greater than that of the channels themselves, erosion is more rapid laterally than radially, so that the general level is automatically preserved within narrow limits.*"

It is certain that the high winds assist in this generalizing or equalizing effect. Were the strata harder, the law would not hold, for perpendicular walls of the radial channels would be exempt from the operation of this equalizing effect.

The clinoplains are not all of the same hight, even in the same district, but they vary with the distance from the bounding mountains to the flood plain and the nature of the material.

Two methods of clinoplain formation may be noted. Aside from that just suggested, where the levelling goes on cotemporaneously with the supply of material from the talus above, there are cases where the clinoplain is obviously derived from the confluence of deltas debouching on the flood plain and working over the materials of earlier clinoplains. This base-leveling continues till the talus is reached and then the general law of distribution again maintains.

One remarkable source of material furnished the clinoplains in the Rio Grande valley through the mediation of the Tertiary deposits, may be noticed. Although the phenomena are widely distributed we will select a single illustration.

The Limitar range, elsewhere described, which lies a few miles north of Socorro, has an axis of andesyte covered with rhylote flows. The north end of the range extends into ridges of rhyloyte diverging to embrace a very irregular area which was evidently at one time the theatre of an intense explosive activity. A vast mass of volcanic breccia and tuff conglomerate is surrounded by what the writer has called "talus conglomerate," the materials of which consist of rounded, water-worn fragments of rhyolyte in a small fine-grained cement of the same. Still outside, the stratification becomes more definite and the beds are alternating tuff and coarser conglomerate.

FIG. 1. Clinoplains of the Limitar mountains seen from Socorro. Ladrones mountains in the distance. Manzano mountains east of the Rio Grande, in the distance.

In one case there is a 28-inch band of variegated flint, having a considerable lateral extent, interbedded in the tuff. The origin of this is a matter for curious speculation; at a distance we supposed it a bed of pitchstone. No other materials not strictly autnchthonous to to the volcano were observed. The dip of this bed is high and away from the theatre of activity in a gentle arch but still outside are bads which dip irregularly and correspond to what has generally been identified as Tertiary. They contain chiefly the same materials as the tuff deposits just described with additions from the near-by portions of the range at large; but, at a short distance from the mountains, only fine-grained materials remain and gypsum and other evidences of marine conditions appear,

It may be that the conditions described are to be understood in the sense that the eruption of the rhyolitic period were during late Tertiary time. At any rate the explosive phases of the eruption took place at a time when the bases of the uplift were washed by the sea and the question as to the contemporaneity of the talus beds and the more distant marly sands must be left open for the present.

Plate X of Vol. I, Bul. Univ. New Mexico, gives a good idea of the talus conglomerates referred to after erosion has laid them open.

The little sketch accompanying this will afford an idea of the topography resulting from the combination of talus plain and clinoplain in the central Rio Grande valley in New Mexico.

When the above article was written the writer had not read the paper by Willard D. Johnson entitled "The High Plains and their Utilization," in the twenty-first Annual Report of the U. S. Geological Survey. The paper referred to gives very interesting description of the "debris apron" and the "gradation planes" which tally sufficiently well with the specific instances given above. The statement, "The bed of the desert stream, then, is not a graded profile merely, but a plane of gradation, and constitutes a topograpihc form which is, in fact, the dominant and characteristic feature of desert landscapes," and that "the debris apron is a plexus of graded stream beds identical in profile" agree well with one type described above. The "mortar bed" structure is also common in the clinoplains of the Rio Grande.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Field Operations of the Bureau of Soils, 1902. By MILTON WHITNEY, Chief; with Accompanying Papers by Assistants in Charge of Field Parties. Pages 842; with 60 plates, 25 text figures, and a portfolio case of 44 folded maps. Washington, Government Printing Office, 1903.

This fourth annual report of the Bureau of Soils, a branch of the U. S. Department of Agriculture, comprises descriptions and maps of selected areas in more than twenty states, and also in Porto Rico, concerning their varieties of soils and adaptation to different crops and to fruit raising. The aggregate of these areas surveyed in 1902 was about 18,000 square miles. Several states, or their agricultural departments, have cooperated with the U. S. Bureau in this work, which is of much practical interest to farmers and horticulturists. W. U.

Geologic Atlas of the United States: Olivet, Parker, Mitchell, and Alexandria Folios, South Dakota, respectively Nos. 96, 97, and 99, by J. E. TODD, and 100, by J. E. TODD and C. M. HALL, 1903.

Completing the first hundred folios of this great work, which for its completion throughout the whole country must require fifty years or more, are these four contiguous folios, measuring half a degree on each side, adjoining the Dakota or James river, in the southern part of

South Dakota, about midway between the Big Sioux and Missouri rivers. The region is of low relief; is enveloped by the glacial drift, with underlying Cretaceous beds; and is of chief economic value for its fertile soil, and of geologic interest for its varied drift formations and its artesian wells deriving their water from the Dakota sandstone. It is to be hoped that many additional folios will be published from surveys by Prof. Todd; and it is deeply regretted that the early death of Prof. Hall prevented the fulfilment of his plans for a general agricultural and hydrographic survey of North Dakota. W. U.

Geology. By THOMAS C. CHAMBERLIN and ROLLIN D. SALISBURY, Heads of the Departments of Geology and Geography, University of Chicago. In Two Volumes. Vol. I. Geologic Processes and their Results. Pages xix, 654; with 24 plates, 3 folded tables, and 471 text figures. New York, Henry Holt and Company, 1904.

As several months have passed since this volume was issued, and yet several months more are to intervene before the other volume, on geologic history, will appear, it is desirable to notice here briefly this half of a great work, philosophic and practical, for advanced students. The plates are (excepting only the first) from the sheets of the Topographic Map of the United States, in progress of survey and publication; and nearly all the text illustrations are from the United States, Canada, and Greenland. The preface states the purpose of the authors as follows:

"Throughout the work the central purpose has been not merely to set forth the present status of knowledge, but to present it in such a way that the student will be introduced to the methods and spirit of the science, led to a sympathetic interest in its progress, and prepared to receive intelligently, and to welcome cordially, its future advances. Where practicable, the text has been so shaped that the student may follow the steps which have led to present conclusions. To this end the working methods of the practical geologist have been implied as frequently as practicable. To this end also there has been frankness of statement relative to the limitations of knowledge and the uncertainty of many tentative conclusions. In these and in other respects, the purpose has been to take the student into the fraternity of geologists, and to reveal to him the true state of the development of the science, giving an accurate and proportionate view of the positive knowledge attained, of the problems yet unsolved, or but partially solved, and of solutions still to be attained." W. U.

A monograph of Marcus island, an account of its physical features and geology with descriptions of the fauna and flora. WILLIAM ALANSON BRYAN. (Occasional Papers of the Bishop Museum. Honolulu. vol. 2, No. 1. pp. 77-139. Map and halftone figures. 1903.)

This island, which was claimed by both Japan and the United States, and was occupied by a colony and military party by Japan for about a year, is said by Mr. Bryan to have now been abandoned by the Japanese, who concede it to the United States. This result is prehaps due in large measure to the hard fate of the party sent there from Japan, who lost sixteen of their number during and after a violent storm which destroyed their rough houses and all their provisions.

The island is located northeast of Guam and somewhat north of a right line from Guam to the Hawaii islands and it may serve as a convenient halfway place for a cable line crossing the Pacific. It seems to be a typical coral reef island, but "is not far from a center of volcanic activity." It is uninhabited. Its size is about 740 acres. Its greatest hight is less than 100 feet and its basis is coral rock. Round its shores are six successive beach lines, which denote gradual elevation. The surface of the interior is generally quite level. Its shape is approximately that of an equilateral triangle with rounded points. It is heavily wooded with cocoanut palm, some of the trees of which reach the hight of sixty feet, and with a few other indigenous species, of which Mr. Bryan reports nine. N. H. W.

Eine neue Familie der Siphoneen aus dem Cambrium von Schantung; von Th. Lorenz [aus dem Centralblatt für Mineralogie, Geologie und Paleontologie. Stuttgart, 1904].

Doctor Lorenz describes in this paper, which is preliminary to a more extended essay with fuller descriptions and figures, some interesting forms of Cambrian Algæ which he has found in a limestone of Schantung in northern China.

From the rows of pores which he found on the slender stems and the dichotomous branching of the tangled branches, etc., he infers that these fossils should be referred to the family of Siphoneæ among the Algæ. They consist of thickish stems which branch on all sides into a tangled mat of fine thread, dichotomously divided

Dr. Lorenz classifies these forms under the family name Ascomaceæ, and he distinguishes two genera, one represented by *Ascoma planeroporata* n.sp., and *Mitscherlichia chinensis*. Fuller descriptions of these will appear in the magazine of the German Geological Society.

G. F. M.

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CORRESPONDENCE.

BLOCK MOUNTAINS IN NEW MEXICO: A CORRECTION. In the article entitled "Laws of Formation of New Mexico Mountain Ranges," printed in the May number of the GEOLOGIST, an omission of a line in the manuscript on page 308, second line from the bottom, destroys the sense. The passage should read: "that the Rio Grande occupies a great anticline and that the strata would be found repeated in the reverse sense on the east side of the river." The passages referred to are in an article on the Socorro and Linitar mountains printed in the Bulletins of Denison University and also in vol. 1 of the Bulletin of the University of New Mexico. One of them runs as follows: "The present course of the Rio Grande in central New Mexico occupies what may once have been the axis of such a fold, while the intersection of the western declivity with the present general level is marked by a fracture zone in which lie the chief centers of overflow."

The rule in New Mexico is that the minor elevations are monoclines and in this case also the anticline is not simple, but is complicated by extensive monoclinal axes of subordinate faulting on either side of the greater (anticlinal) axis. C. L. HERRICK.

THE LOESS. The interesting articles of Prof. Wright and of Miss Owen in the April number of the GEOLOGIST express my views and fully coincide with the conclusions I had arrived at over twenty years ago regarding such deposits along the Missouri. I have been familiar with the Missouri river for forty-five years and until two years ago I made trips on Missouri steamboats every year for fifteen years from its mouth to Kansas City and St. Joseph.

Von Richthofpen viewed China from a very plausible standpoint as mentioned by professor Wright. In 1877 Von Richthofen published a book on China in which he advanced his æolian theory, and considered that if it was true in China, it would prove so everywhere else.

In the *American Journal of Science*, in 1879, professor E. W. Hilgard had an instructive article on the loess of the Mississippi valley in which he supports the aqueous theory of the origin of the Loess.

In the same volume of the *Journal* there is a notice of similar views advanced by J. E. Todd before the American Association, also supporting the aqueous theory.

In the same volume of the *American Journal of Science* the writer had an article also supporting similar views. In this I was supported by the late J. D. Dana. I have seen the loess from near the head of the Missouri to its mouth, and have seen good evidence of stratification in it, which could only take place by the agency of water. At St. Charles, Missouri, near the Wabash depot, there are seen alternate beds of clay and sand evidently proving different periods of deposit.

On the recently formed banks of the Missouri are seen deposits lying horizontal and of uniform thickness and each layer easily separate from the next adjacent. There are also iron stained layers, clay beds and sandy beds, just as the loess shows, all proving aqueous agency.

On every trip on the Missouri, whenever the boat would tie up, I would step ashore and notice the structure of the river bank and the contents of the wreck heaps. On every wreck heap I would find among the trash hundreds of land shells, mostly Helices, and sometimes the small Pupa all being land shells, and rarely did I find a Planorbis or Lymnea. The Succinea I would also find. These shells are also found with the loess. Those in the river were washed down from the hills by the rains, and the shells in the loess came the same way. It is very rarely that the loess is found more than six miles from the Missouri river, and on the south side not often a mile. In St. Louis county it is spread out over ten miles because the plain is not so high above the river.

At two places in southern Missouri I have seen what appears like glacial drift, viz: at Big Salt Spring, Saline county, fifteen miles from Missouri river, and in St. Louis county at the head of Hamilton creek there are pebbles on top of a hill probably 250 feet above the Missouri. The velocity of the Missouri varies from two to three miles per hour at low water to ten at high water, the slope about 0.88 feet per mile for high and low water.

Estimates made by Colonel Suter at St. Charles show that for one year the amount of sediment carried past would amount to one square mile 197 feet deep.

The depth of the valley between the hills to the rocks below is from 70 to 100 feet and 40 to 80 feet below the bed of the river: at St. Joseph about 40 and at St. Charles nearly 100.

The width of the valley between bluffs is about the same from St. Charles to Boonville about 2¾ miles; at Waverly it is 5 miles, at Sibley 4½, at Kansas City 2½, at Leavenworth 4, at St. Joseph 4, at Rulo 9, at Omaha 5, at Sioux City 8. G. C. BROADHEAD.

Columbia Mo., April 2, 1904.

PROPOSED EXAMINATION OF THE ARID BELTS OF SOUTH AFRICA AND SOUTH AMERICA. In thinking over your highly suggestive and almost convincing paper on the causes of the Glacial epoch, it strikes me that in view of the difficult conservation of the evidences of glacial action and of glacial deposits in the tropics with their excessive rainfall, it would be of special interest, and at least next-best, to have the adjacent arid belts studied with respect to former glaciation. It is true that even there, glacial scorings would hardly be preserved, because of the destructive effect of the extreme changes of temperature prevailing there, which cause even cobbles to explode so frequently. But all other evidences of past glaciation, such as boulders, moraines, drumlins *et id omne*, should be particularly well preserved on account of the absence of the erosive action of heavy rainfall. We have but very few observations on the details of surface conformation in the arid belts, except in respect to aeolian effects. Sven Hedin had a good opportunity in central Asia, and he has a good deal to say about detrital formations that impeded his progress, but it is impossible to draw any conclusions from his records as to how these were formed. It may be that the aeolian surface mantle obscures, in a measure, the previous glacial features, but close observation ought to be able to unravel them from the existing covering. It ought at least to be possible to get as much evidence of glaciation in the tropics and the arid belts, as is now brought forward from the Permian, and thereabouts, against your views. Would it not be possible to get some one who is an enthusiast on Glacial epochs to set on foot a systematic exploration of such promising fields as arid South Africa and South America? The Kalahari on the south and the Sahara on the north would seem very promising, if not specially inviting to the average explorer; but one or two men above the average could surely be found; and if some of our rich men would direct their benevolence into that channel and thus aid in settling this leading unsolved problem in the past history of the globe, immediately preceding the present era, it would redound much more to their permanent glory than even reaching the North pole. As I understand it, the Carnegie Institution will not initiate such researches, but once on foot might also extend help to a talented explorer to complete his work.

But the man who undertakes this must be no tyro, and have no preconceived notions to bolster up; he should possess the moral determination and physical endurance of Hedin. It is a prize well worthy of the ambition of any young geologist, whether the result of his researches should be to prove or disprove your theory; and if it should take a life time to settle the question, it would be a life time much better spent than are those of some of our "scientific hay-gatherers" who keep accumulating undigested raw material.

I sincerely hope that some Meecaenas to endow this research will be found; if so, the man for the work will turn up, and may be carefully selected by the Carnegie Board of Control.

Yours truly,

E. W. HILGARD,
University of California,
April 4. 1904.

To Dr. Marsden Manson,
San Francisco, Cal.

PERSONAL AND SCIENTIFIC NEWS.

Dr. G. P. Grimsley has charge of the Kansas mineral exhibit at the Louisiana Exposition at St. Louis.

Professor W. M. Davis, Harvard University, was recently elected a member of the National Academy of Sciences.

Dr. James Douglas delivered the class day address to the graduating class of the Michigan College of Mines at Houghton on April 22d.

DR. JOHN C. MERRIAM, of the University of California, started for Europe the middle of May, visiting Washington and New York en route.

PROFESSOR G. D. HARRIS, of Cornell University, is state geologist of Louisiana, and has been engaged in active field work during the winter.

PROFESSOR HENRY LANDES, STATE GEOLOGIST OF WASHINGTON, will return to Seattle in August after a year spent in study at the University of Chicago.

FRANK CARNEY, of Ithaca, N. Y., has been elected to the chair of geology at Denison University, Granville, Ohio, recently resigned by Dr. T. L. Watson.

DR. CHARLES H. STERNBERG, Lawrence, Kansas, has a large collection of Cretaceous reptiles and fishes from the Chalk of Kansas which are just now for sale at greatly reduced prices. Vertebrate paleontologists will be glad to know of this opportunity.

DR. THOMAS L. WATSON, since 1901 professor of geology in Denison University at Granville, Ohio, has resigned to accept the chair of geology in the Virginia Polytechnic Institute at Blacksburg, Virginia. Dr. Watson will assume charge of his duties at the Polytechnic in September, 1904.

DR. RALPH ARNOLD, OF THE U. S. GEOLOGICAL SURVEY, will spend the early summer in detailed stratigraphic and paleontologic work for Dr. Dall on the Pacific coast. Later in the season he and professor Newsom, of Stanford University, will complete the mapping of the Santa Cruz quadrangle, California.

DR. JAMES PERRIN SMITH, OF STANFORD UNIVERSITY, will leave for Washington, D.C., the latter part of May, where he will spend a part of the summer in studying the Mesozoic collections in the National Museum. He will return to California via southeastern Idaho, stopping off a few weeks for field work in the Triass of that region.

MESSSRS. R. S. BASSLER AND W. C. PHALEN of the department of geology in the U. S. National Museum have recently severed their connection with that institution to accept positions on the U. S. Geological Survey. Mr. F. A. Lucas of the biological department has also resigned to accept the position at the Brooklyn Institute, New York, vacated by Dr. A. G. Mayer, who, in his turn, becomes director of the biological station at the Dry Tortugas.

THE ANNUAL GEOLOGICAL EXCURSION TO DEVILS LAKE AND THE DALLES OF THE WISCONSIN, taken jointly by certain classes in geology of the University of Wisconsin and of the Northwestern University, was held on April 28th, 29th and 30th. About forty students took part in the excursion, which this year also visited the newly opened iron mines of the Baraboo range. The excursion was led by professors Fenneman and Leith, of the University of Wisconsin, and professor U. S. Grant, of Northwestern University.

UNDER THE NEW LAW OF ORGANIZATION of public education in New York state the Department of Science has been created by the regents of the University. This department embraces, with other things, the directorship of the state museum at Albany and the resultant scientific research. Dr. John M. Clarke has been made director of the department, and also state geologist and paleontologist, thus uniting again in one person the functions that were discharged by Dr. James Hall. Dr. Clarke, however, as director of the Department of Science, will have a wider field of activity.

ACCORDING TO DR. E. O. HOVEY, who exhibited various lantern slides at a late meeting of the New York Academy of Sciences, the field evidence indicates that the present active cone of the Grand Soufrière is closely analogous to the new cone and spine of Mont Pelé, Martinique, that is to say, that it had been pushed up bodily into its present position, or had welled up through the conduit in such a viscous condition that contact with the atmosphere rendered it too rigid to flow. At the base of the cone on the north, there is a gently rising flat area, apparently the segment of a circle indicating the position of a part of the rim of a crater in existence before the construction of the present cone.

AT THE MEETING OF THE 16TH OF MAY OF THE SECTION OF GEOLOGY AND MINERALOGY of the New York Academy of Science, Dr. W. D. Matthew exhibited a series of foot bones illustrating the evolution of the camel, recently installed in the hall of vertebrate paleontology of the American Museum of Natural History. This series corresponds to that illustrating the evolution of the horse, and is almost equally complete.

It shows the derivation of the camel from small primitive four-toed ancestors which were exclusively North American in habitat. The earliest known ancestors are tiny animals no larger than a rabbit. The camels reached their maximum size and abundance in the Pliocene epoch, when they were much larger than the modern camels. Then they spread to the other continents, disappeared entirely from North America and became smaller in size and far less numerous in species elsewhere.

DR. GEORGE P. MERRILL OF THE DEPARTMENT OF GEOLOGY in the U. S. National Museum, was in western Mexico during February of this year supervising the work of making a model of the great iron meteorite at Ranchito, some eleven miles south of Bacubarito, in the state of Sinaloa.

The cast from this model will be exhibited by the National Museum, together with one of Lieut. Peary's Melville Bay irons, at the Louisiana Purchase Exposition.

The public will thus be given an opportunity of viewing facsimiles of the two largest meteoric masses now known. A small collection of meteorites mainly from falls within the Louisiana Purchase area accompanies this exhibit.

Incidentally it may be remarked, that the Mexican Government has taken possession of the Ranchito mass and built around it a substantial stone house to protect it from the ravages of collectors.

EXHIBIT OF RADIO-ACTIVE MINERALS. The United States Geological Survey has sent out a circular preparatory to the exhibit which, under the management of Mr. Geo. F. Kunz, the survey will make at the Louisiana-Purchase Exposition during the coming summer at St. Louis, asking co-operation of all who are interested in radio-activity. The collection which will be on exhibition will be the most notable ever made.

"It will include specimens of every known radio-active substance, whether obtained from minerals and ores, from mineral waters, or from petroleum wells. There will be shown also authentic specimens of radium compounds that have been made by noted investigators. Everything relating to the source, manufacture, and application of radium will be exhibited, including all chemicals obtained from the separation of various radium compounds, and all instruments and devices with which it is proposed to apply radio-activity in medicine, science, and the arts. An interesting feature will be the portraits and the publications of celebrated radium discoverers and investigators, together with photographs of their laboratories and apparatus, and autograph letters from some of them."

FIELD COURSES IN GEOLOGY. A joint announcement has been issued by Harvard University, University of Chicago, Columbia University, Johns Hopkins University and the Teachers' School of Science of the Boston Society of Natural History, setting forth the various courses of field study that will be conducted by these institutions in the season of 1904. Four such courses will be given by the professors of Harvard; four by the University of Chicago; one by Columbia University; three by Johns Hopkins and two by the Boston Society of Natural History. Each of these courses will be under the guidance of a geologist familiar with the geology of the region studied. For the purpose of making the trips useful to all participants the parties are limited to ten or twelve. The regions to be examined range as far west as Hawaii and as far east as the Atlantic seaboard.

Such study excursions are coming to be common. As the Geological Society of America has no meeting this (coming) summer, and as the American Association for the Advancement of Science has its regular meeting in the winter, it may be expected that many will resort to these courses. The terms of admission and the costs of each may be learned by application to the various geological departments. In many cases the participants are required to prepare for publication a descriptive thesis on the geological phenomena seen and studied.

A CANOE TRIP DOWN THE YUKON RIVER FROM DAWSON TO ANVIK. Dr. Arthur Hollick, in giving the preliminary results of his recent exploration, before the New York Academy of Science, Section of Geology and Mineralogy, said in brief:

"The Yukon river occupies what was until quite recently a broad estuary. Subsequent elevation of the land resulted in the draining of the estuary and the formation of the present river valley, which has cut its way down through the estuary deposits, leaving these as broad benches or terraces. Mastodon and other remains of extinct animals indicate the Pleistocene age of the deposits. One of the finest exposures is at the 'Palisades,' just below Rampart.

"The width of the river varies from one to ten miles, and the main channel is constantly shifting. It pursues a meandering course, sometimes impinging on one side of the old valley, sometimes on the other, and for long distances flows through the middle. Where it occupies the latter position, it is generally broad, with a current of about four miles per hour, and filled with innumerable wooded islands, mud flats and sand and gravel bars, which render navigation more or less a matter of guess-work, on account of the impossibility of telling where the main channel flows and the liability of running into a blind slue or long circuitous channel around an island. It was cften found advisable to climb up the river bank to a considerable elevation in order to determine, by means of an extended view, where the correct course lay. Where hard rocks were exposed along the river banks, or a short distance away, these were subjected to careful examination in regard to their lithologic, palœntologic and stratigraphic characters.

"Amongst the interesting results obtained were, 1st, the determination of the Tertiary age of certain sandstones above Rampart; and 2nd, the determination of the Cretaceous age of other sandstones and shales further down the river in the vicinity of Nulato. At one locality, a unique fossil flora was found, totally different from any heretofore known in America, consisting of cycads of Lower Cretaceous types, mixed with angiosperms belonging to what have always been considered upper Cretaceous types.

"Only a preliminary study has been made of the material collected, which will eventually be carefully examined and reported upon for the United States Geological Survey.

"The paper was illustrated with about seventy lantern slides, showing the principal topographic and geologic features of the route."

UNITED STATES GEOLOGICAL SURVEY.

Among the exhibits made by the Survey at St. Louis is a series of charts illustrating the origin of ore deposits. Of these charts those devoted to iron, copper and lead and zinc are especially interesting and complete. The charts have been prepared by C. R. Van Hise, C. K. Leith and W. N. Smith.

Bulletin No. 227 is entitled "The United States Geological Survey: its origin, development, organization, and operations." It will be distributed at the Survey exhibit at St. Louis.

A large party of topographers, acting in co-operation with the Maryland Geological Survey, has begun work in that state. It is expected that during the present season this party will complete the mapping of ten quadrangles, among which will be four on the eastern coast of Maryland, thus completing the topographic survey of that part of the state.

A hydrographic manual has recently been issued as Water Supply and Irrigation Paper No. 94.

Field assignments for 1904 in Alaska. The appropriation for work in Alaska was increased from $60,000 to $80.000 by the last Congress. This year nine parties, with three subparties, will be engaged in topographic and geologic work in Alaska. The parties are assigned as follows:

1. Southeastern Alaska will be studied by C. W. and F. W. Wright.

2. The placer district about Cook inlet will be studied by Fred H. Moffit and E. G. Hamilton.

3. The oil and coal fields of southwestern Alaska will be studied by G. C. Martin and R. W. Stone. This party will be accompanied by T. W. Stanton, who will make extensive collections of fossils.

4. T. G. Gerdine, R. B. Oliver and W. R. Hill will devote the season to topographic mapping in the Seward peninsula.

5. The coal deposits of cape Lisburne and the tin deposits of the York region will be studied by A. J. Collier.

6. L. M. Prindle and Frank L. Hess will study the placer districts of central Alaska.

7. Topographic mapping from Eagle to Rampart will be undertaken by D. C. Witherspoon.

8. C. W. Purington and Sidney Paige will investigate the placer-mining methods in vogue in Alaska.

9. Alfred H. Brooks, geologist in charge of the division of Alaskan mineral resources, will devote his time chiefly to administrative work and will visit most of the above field parties.

The Mount Stuart (Washington) folio has recently been published. The author is George Otis Smith, and the folio describes an area in central Washington on the eastern slope of the Cascade mountains. Within this area are the three principal gold mining districts of central Washington, and copper, silver, nickel, quicksilver and coal also occur.

INDEX TO VOL. XXXIII.

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ERRATA FOR VOLUME XXXII.

Page 145, line 13 from the bottom, for "specially" read specifically.

Page 148, line 24 from the bottom, after "island" insert (See Plate XXI).

Page 151, line 5 for "not" read now, and for "pre" read post.

ERRATA FOR VOLUME XXXIII.

On Page 44, line 20, for "preglacial" read postglacial.

On Page 77, sections 3 and 4 are respectively SW of Tea and of Lenox.